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Railway Electrical Engineer

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Car Lighting Equipment

The upward trend of the market for car lighting equipment is clearly pointed out by the passenger car orders for 1920. A total of 1,115 cars was ordered by Class 1 roads during the year and 666 by other companies and private car companies in the United States, including the Pullman Company. The total for the year's domestic order was 1,781, a figure which compares quite favorably with the orders in 1917 and 1918 as well as 1919 In 1917, this figure was 1,924; in 1918 it was 1,480 and in 1919 it was 306. A complete record of the kind of lighting equipment used on these cars is not available, but out of a total of 1,671 cars, 1,534 are electric lighted. 40 are equipped with combination gas and electric light, 94 are gas lighted and three are equipped with oil lamps.

This indicates the rate at which electric lighting is superseding gas and oil. The total number of cars purchased, although still below any year from 1909 to 1916 inclusive, shows a tendency toward a return to normal conditions. It is more than possible, too, that the lean years just past will cause the purchases during the next few years to exceed a normal rate.

Automatic Train Control

For many years the question of automatic train control has received rather indifferent consideration, except after each disastrous rear end collision where the subject would come to the front for a time and then recede again. Recently, however, the Interstate Commerce Commission has taken an active interest in the matter and in conjunction with a committee appointed from the American Railway Association it may be expected that some definite results from an intensive examination into the various systems will be forthcoming shortly. The problem that confronts the investigating committee will be the determination of the virtues and weaknesses of the various automatic train control systems which are quite numerous. Needless to say only those that can successfully pass the most rigorous tests should be given consideration.

Some of the control systems involve more or less wiring upon the locomotive which, in the natural order of things, will fall to the electrical department to maintain, should such systems be looked upon with favor by the committee. The stationary portion of the equipment which is installed in connection with the signal system naturally falls to the signal department to maintain. It is unfortunate that such a division of maintenance seems inevitable, for it presents an opportunity to dodge responsibility. At all events it will be interesting to watch the results of this dual maintenance problem, or to see what methods may be adopted to avoid this division of responsibility.

Results of Electric Operation

In spite of price fluctuations, temporary depressions and various forms of agitation and disturbance, railroad traffic from year to year continues to increase about as usual and during the past few years this increase has been taken care of for the most part by intensive development of one kind or another. Just how much electrification will be used to take care of traffic increase is a matter for speculation, but it is a form of intensive development, and roads already electrified are showing results that are most encouraging. Each of the electrified roads has helped to show that electric operation is desirable under certain circumstances and interest has been centered during the past year on the Norfolk & Western and the Chicago, Milwaukee & St. Paul. Tunnels on these two roads did restrict steam operation, but operation on neither road was circumscribed by tunnel and terminal requirements. For this reason they deserve special attention.

Results of operation on the Norfolk & Western are described elsewhere in this issue and they show that in spite of the many difficulties incurred by the fact that the road was a pioneer in the use of heavy electric traction, the use of it has been successful and has made it possible to develop traffic that would be impossible to handle under steam operation. Electric operation has been equally successful on the Chicago, Milwaukee & St. Paul and an indication of the results may be had from the following statements made during the past year by some of the St. Paul operating men who are most familiar with the problems:

"Nearly 30 per cent more tonnage can be handled by electric operation in about 80 per cent of the time it formerly took to handle the lesser tonnage by steam operation."

"One of the marked economies effected by electrification is the reduction of train and enginemen's expense, on account of the increased ton-miles per train mile and per engine-mile and the reduction of equipment repair and roundhouse expense."

"As to ease of starting trains, this feature of electric operation is noticeable, conducing to increased comfort of passengers."

"The technical result of the electrification has been

quite a success. The financial result, due particularly to fuel and labor conditions, and the indirect value due to publicity of this operation, are equally satisfactory."

"Even allowing for the increased investment charges, the items of operating expense, depending directly upon motive power, are so reduced and additional benefits indirectly obtained are so great as to justify consideration of extending the electrification even on sections with easier grades."

Operating conditions on the Norfolk & Western and the Chicago, Milwaukee & St. Paul are very different, in that one may be likened to a big yard with very heavy switching operations, while the other is a long section of single track road on which the length of locomotive divisions has been doubled. Each new application of electric traction presents an individual problem, but many difficulties common to all roads, have been and are being worked out on these two roads, and a study of the results obtained will be a material aid to other roads that will adopt electric operation on similar sections of their own lines as soon as it becomes financially feasible so to do.

The Goodwill Factor

The subject of electrification is invariably approached with the single thought in mind—will it pay? In the determination as to whether it will or will not pay, all of the factors to be considered are seldom if ever given attention, at least not until a road gets to the point where the subject has become so pertinent that it will no longer stay in the background. In fact, it is not easy to make a complete list of these factors, for some of them are most subtle and intangible and yet withal are capable of exerting the most powerful influences.

It is a recognized fact, and one which is conceded even by steam locomotive advocates, that electric equipment is capable of handling a greater volume of traffic over the same track in the same time than can steam power. When steam operation reaches a point where the passenger traffic is so congested that a brief detention of one train results in the detention of the fourth or fifth trains following, it is pretty clearly demonstrated that the limits for steam operation have not only been reached but that they have been exceeded. Such conditions are not hypothetical but are real; there are steam roads where such delays are regular daily occurrences to the increasing exasperation of the traveling public.

If there is one thing above all else that the common carriers should cherish it is the goodwill of the public, for intangible though it may be there is no denying that it is a powerful ally. When any road arrives at a point where it cannot move its passenger traffic on schedule time and where a train on time is the exception and not the rule it is no longer a question—can that road afford to electrify, but rather—can that road afford not to electrify.

There is no secret about the successful operation of electric trains under the conditions described. It is simply a question of train acceleration. Electric trains are capable of accelerating far more rapidly than any steam train; a detention of one train need not extend to following trains unless the detention is one of unusual length, even then the first trains would be off and out of the block before a steam train could reach full speed.

Delays day after day, month after month, are conducive to anything but goodwill on the part of the public. Hence the factor of public goodwill becomes one of the most important in the consideration of the electrification problem.

The Railroads and the Business Depression

The railroads are going through a most critical period. The government guaranteed the returns to them up to September 1, 1920, since which time the railroads have had to paddle their own canoes. Had the freight traffic remained as heavy as it was earlier in the year, the increased freight and passenger rates, which went into effect near the end of August, might have given a sufficient return to restore the credit of the roads in the eyes of the investors and attract new capital. Unfortunately, however, traffic has fallen off greatly during recent weeks, and the railroads, hampered by shortage of cash and lack of credit, find themselves unable to go ahead with their programs of rehabilitation. This is exceedingly unfortunate because there seems to be little question but what they will be faced with a heavy traffic later on in the year which they will be unable to handle unless their facilities can be improved and enlarged meantime.

The financial difficulties of the roads have been further increased by the fact that the Treasury Department has refused to pay them several hundred million dollars on the guarantees until all of the claims between the railroads and the Railroad Administration can be adjusted and settled. A bill has been introduced in Congress which it is hoped will pass and will overrule this decision of the Treasury Department. Then, too, some of the states have refused to allow the increase in rates on intrastate business; this in spite of the fact that three state commissioners sat with the Interstate Commerce Commission during the rate hearings and agreed with the commission in its decision as to the necessity for increases in freight and passenger rates.

The *Railway Age,* realizing that a buying movement on the part of railroads would be a large factor in stabilizing industrial conditions, is urging the railroads wherever possible to purchase such equipment and materials as will enable them to handle business satisfactorily later on; there will be an added advantage in this in that business along all lines will be stimulated and sufficient traffic will be created to keep the railroad machine working at nearly its capacity. On the other hand, the *Railway Age* is also urging all those producers who can possibly ship materials now to do so. If they do not, it may not be possible for the roads to handle the traffic satisfactorily or expeditiously when it is offered later on.

The Railway Business Association has had a Committee on Stabilization of Railway Purchases which has just issued an extensive report, the conclusion of which may be summed up in the following words: "As causes of industrial and commercial depression, crop failures and money panics have been made unlikely. The next step toward continuity of general business and employment is to stabilize railway purchases."

The railroad managements have a great responsibility in helping to stabilize business conditions.

The Two Tracks Separate Between Bluestone and the Elkhorn Tunnel

The Pioneer of Heavy Electric Traction

Norfolk & Western Has Solved Many Maintenance and Operating Problems During the Past Five Years

WHEN electric operation on the Norfolk & Western is studied, the proper consideration should be given to a certain few fundamental facts. For example, locomotive maintenance costs have been high but it is logical that they should have been under the circumstances. The locomotives were pressed into a service heavier than anything which had been done before or has been done since and for that reason there was no precedent to follow in designing equipment. Furthermore, the maintenance of any machine is to a large extent dependent upon the amount of work done by the machine, and the work done per mile and per day is greater for the Norfolk & Western locomotives than for any other locomotives, steam or electric. For example, about 60 per cent as much power is used by 12 locomotives operating over 28 miles of line on the Norfolk & Western as is used by 42 locomotives operating over 440 miles of line on the St. Paul. The power consumption on the Norfolk & Western during 1919 was 67,395,000 kw. hr., while that on the St. Paul was about 120,500,000 kw. hr. During 1918 the N. & W. electric locomotives used 74,325,992 kw. hr. while the St. Paul used about 130,177,000.

In spite of many difficulties the electric system has been made to give excellent results and the operating

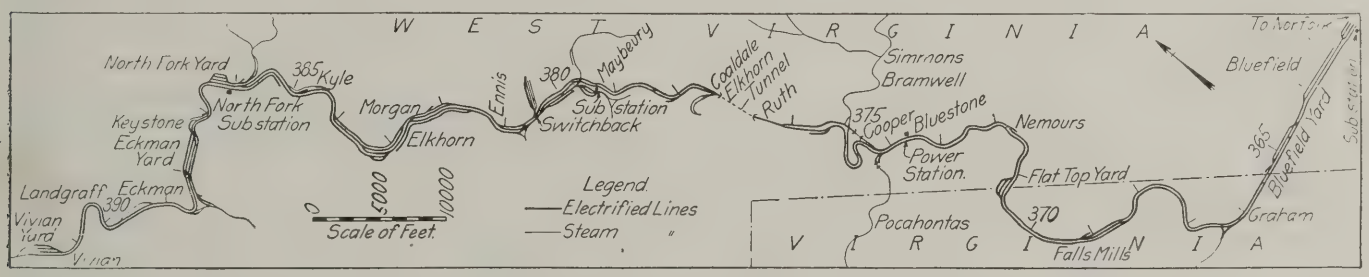

Fig. 1—Map of the Electrified Section. About 60 per Cent of the Line is on Curves

men agree that it has been the only practical solution for the operating problem on this division.

Construction on the electrified division was started in 1913 and completed in 1915. The section electrified is about 29 miles long and is spoken of as the Elkhorn grade. It is a part of the main line in the southern part of West Virginia and extends from Bluefield to Vivian. The section is all double tracked except in the Elkhorn tunnel, which is single track. There are also a number of branches into the coal workings and a large amount of third track or passing sidings and yard trackage. The

total amount of track equipped for electric operation is 108 miles. The grades on the line are heavy, varying from 1 per cent at the west end to 1.5 and 2 per cent up the grade, to and through the summit or Elkhorn tunnel, a distance of about ten miles. From the summit the line descends on a 2.5 per cent grade for approximately a mile and then rises again at the ruling rate of about 0.25 per cent for a little more than ten miles and finally up a 1.22 per cent grade for three miles into Bluefield, the eastern end of the division. Fully 60 per cent of the entire division is on curves, the maximum curvature be-

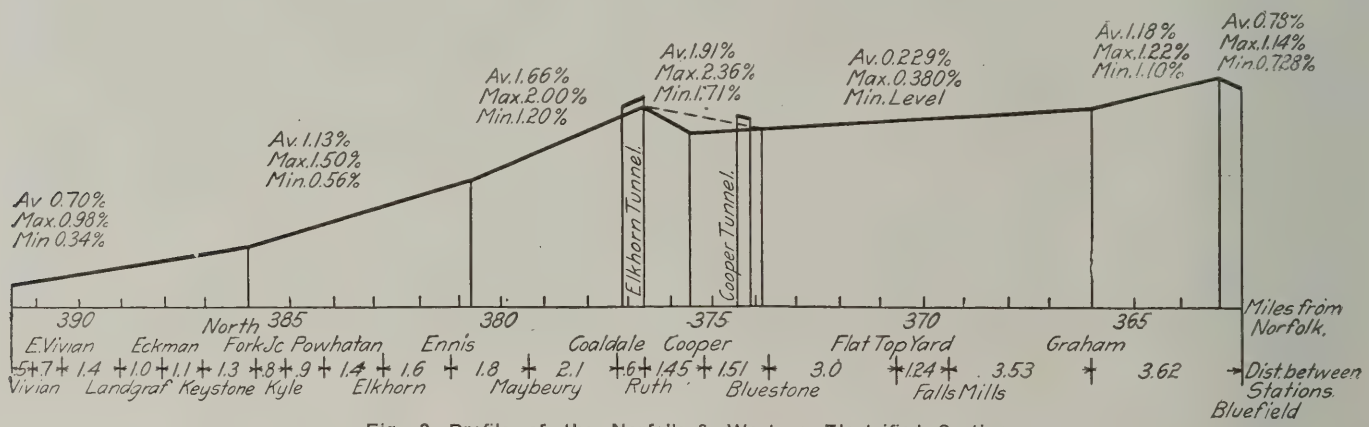

Fig. 2—Profile of the Norfolk & Western Electrified Section

ing 12 degrees on main line and 16 degrees on sidings. The east and west bound tracks are all on the same right of way except for about two miles west of Bluestone. They separate at Bluestone and come together again just at the eastern entrance of the Elkhorn tunnel, the line being single track through the tunnel.

Class of Service

The function of the electrified section is that of collecting from the mine sidings and yards in the coal fields the entire eastbound coal tonnage and transporting it up the grades and over the summit to the classification yard at Bluefield, which is a division point. The coal is partly classified at Bluefield and then moved east by steam power to the various destination points, chiefly to the Norfolk & Western marine shipping pier at Lamberts Point near Norfolk, Va. All coal traffic originates west of the Flat Top yard, about 6 miles east of the summit of the heavy grade, and although a large amount of the coal which originates on the electrified division goes west the shipments to the east constitute the bulk of the traffic handled electrically. Some coal originating east of the summit is shipped to the west and this is also handled by electric service to yards near the western end of the electrified section. There is probably more Norfolk & Western coal shipped to the west than to the east but over the electrified section the total eastbound tonnage is now about six times as great as the westbound. About 80 per cent of the eastbound traffic originates between Eckman and Coaldale. (See profile.)

Steam road engines are still used over the electrified section for through merchandise freight and for passenger trains, but electric locomotives are used regularly as helpers on three eastbound passenger trains for most of the through freight trains. An electric helper is also occasionally used to help other delayed passenger trains to make up time. The principal duty of the electric locomotives, however, is to make-up and haul extra, eastbound coal trains over the electrified division into Bluefield.

Reason for Electrifying

Decision to electrify the Elkhorn grade was made because this section of the road restricted the amount of main line traffic that could be handled. The increasing traffic together with the heavy grades and added tunnel complications had made it practically impossible to handle the traffic over this section with steam power. Because of the mountainous country through which the division runs it was not economically practicable to build more tracks and the only solution lay in handling heavier trains and moving them at higher speeds. Two electric locomotives now haul a 3,250-ton train up the 2 per cent grade at 14 m. p. h. where originally three mallet loco-

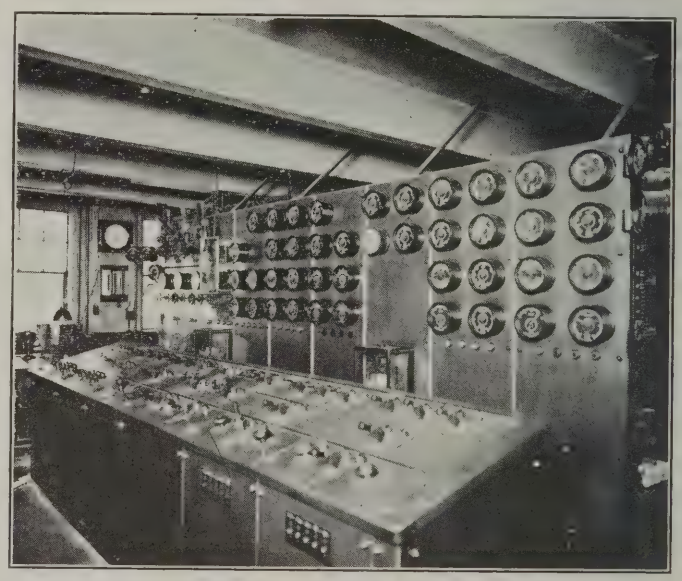

Fig. 3—Main Switchboard in the Power House at Bluestone

motives were used at a speed of about 7½ m. p. h. The effect of increased speed was especially marked at the single track Elkhorn tunnel, which is over 3,000 ft. long on a 1.5 per cent grade. On account of ventilation requirements, under steam operation, it was necessary to reduce the speed up the grade to about 6 m. p. h. requiring about seven minutes to clear the block. With electric operation this movement is made in about three minutes

Since electric operation was installed the Elkhorn grade has not caused restriction of main line traffic.

Train Operation

Several different kinds of operation have been tried during the past five years. All trains do not do the same

Fig. 4—The Boiler Room in the Power House Showing Automatic Stokers

work now but following a locomotive and train crew through a typical day's work will give an idea of how the coal trains are now handled.

A train of westbound empties, consisting of from 90 to 110 cars, is made up by a steam switcher in the Bluefield yards. The electric crew take their locomotive to the caboose track where they pick out their caboose and couple it on the rear of the train. The locomotive then goes to the head end of the train and proceeds out. The train is run at both the 14 and 28 m. p. h. speeds from Bluefield through the Elkhorn tunnel.

The train then drops down the heavier grade regenerating power to the line. The empties are set off at various sidings on the way down the hill. When the last of the empties are to be set off, the caboose is uncoupled on the main line and is allowed to roll down the hill until it meets the locomotive as it comes out of the lower end of the siding. They then proceed to the Eckman yards. Had they taken westbound tonnage from Bluefield, they would probably have proceeded to Vivian.

At Eckman all or a part of a 3,250-ton train is made up and taken up the grade to the Elkhorn tunnel with the aid of a pusher. If only a part of a full tonnage train is taken east from the Eckman yards the balance will be picked up at other points on the way to the summit.

The method of starting such a train is particularly interesting. When the engineer on the front end is ready to start he backs the train against the pusher. At this signal the engineer on the pusher applies power forward and holds with full load current on the motors until the front end locomotive has taken its share of the load. The pusher then starts forward automatically.

A special hook is used for uncoupling the pusher at the top of the grade. Just before the top of the grade is reached the brakeman uses this hook to pull up on the coupling pin. The pin is loose for a moment after the pusher stops pushing and before it starts to regenerate and at this moment the pusher is uncoupled and goes back for another train.

The head-end locomotive then regenerates power down the steep grade east of Elkhorn tunnel. With a full tonnage train the one locomotive returns practically full load current to the line.

The train then proceeds to Flat Top yard where the procedure depends on whether the crew is making its first or second trip for the day. In the former case, it is usual for the train to be left at Flat Top, the locomotive returning west, either light, with empties or exceptionally with westbound loads. In the latter case the train fills out to 4,700 tons at Flat Top yard and proceeds to Bluefield, a pusher being provided on Bluefield Hill. At Bluefield the time allowed for preparing locomotive for its next trip is forty minutes.

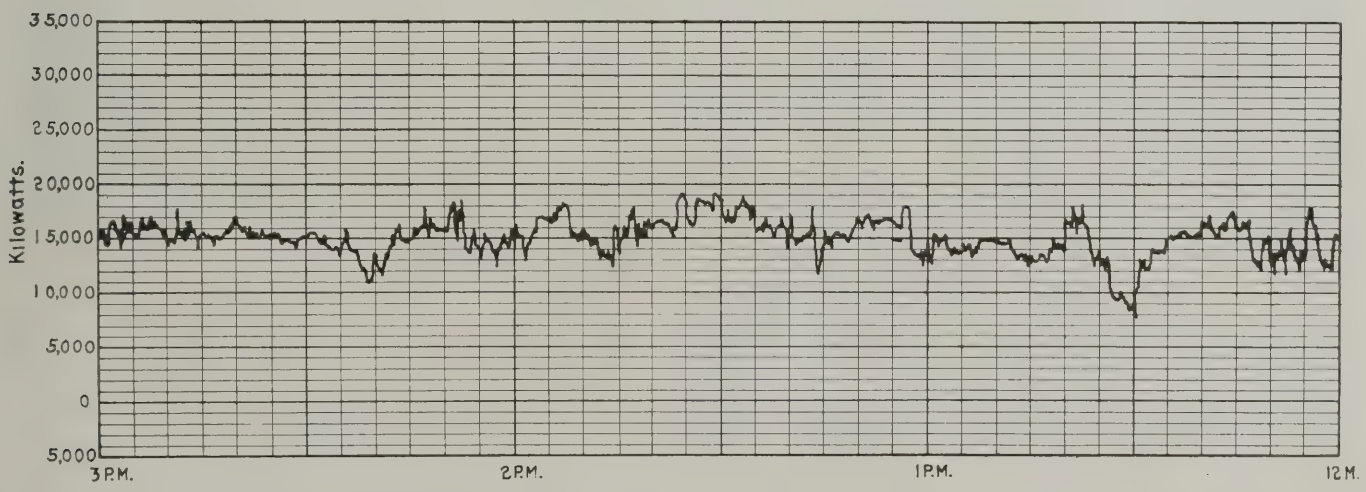

Fig. 5—A Typical Section of the Load Curve

There is a more or less prevalent idea that so much

time is required by the locomotive engineer in changing from the pulling to the regenerating connection that the train may exceed synchronous speed on the down grade before regeneration can be started. This change can be made in a few seconds and even though it were not made, the locomotive would regenerate power in the pulling connection. The only reason for having a special regenerating connection is that when the pulling connection is used for regenerating, there is a bad phase unbalancing in the phase converter and motors and the total amount of power that can be regenerated is reduced.

Since the system was put in operation in 1915, more than 50,000 trains have been taken over the electrified section without a regeneration failure. Retaining valves are not used.

Power Despatching

All of the power for the electrified section is developed in one steam power house located at Bluestone. From the power house it is transmitted at 44,000 volts, 25 cycle single phase to five substations where it is stepped down to 11,000 volts and delivered to the trolley. Four turbine driven generators rated at 10,000 kw. each are used to develop the power, two of these machines carrying the load for the greater part of the time. The load sometimes changes from nothing to 25,000 kw. in a few minutes. One 3,250-ton train requires from 12,000 to 14,000 kw. for starting on a 2 per cent grade and about 8,000 kw. are required to move this train up the grade at 14 m. p. h. Half of this power is used by each of the two locomotives and about one and one-half minutes are required to reach the speed of 14 miles. Naturally it is difficult under these circumstances to operate with a high load factor. A system of operation has been adopted, however, that has resulted in 50 per cent load factor and a coal consumption of something less than 3 lb. of coal per kw. hr.

A record of all electric train movements is kept by the power despatcher at the power house. Telephones are located along the right-of-way at all important signal towers or bridges. When a conductor has received his train he calls the power house and reports that he is about to start east or west from a certain place with a train of a certain tonnage and number of cars. This is recorded by the power despatcher on a log sheet and he also has stokers and blowers speeded up to meet the coming increase of load. If it is not practicable to carry the increase of load with the number of boilers in service, the power despatcher asks the conductor to delay starting for a few minutes. If for any reason a train is stopped at a signal for more than three or four minutes, the power despatcher is again informed that it is about to proceed. This method permits the power house operator to anticipate the load, to forestall excessive peak loads and as a result operate with a minimum number of boilers and generators and obtain a high load factor and relatively high efficiency.

Changes in Power House Equipment

Relatively few changes have been made in the power house equipment since the plant was put in operation. The retaining wall shown in the foreground of Fig. 6 was added to keep water out of the basement and the screens in the intake channel were improved. Originally only the screens at the intake entrance were used, but these were found to be insufficient and the finer screen shown in Fig. 7 was placed in the intake channel. The screens are raised periodically and washed with a hose, another screen being let down while the first is being washed.

At rare intervals the regenerated power exceeds the power used by trains. When this happens, relays connect water rheostats into the circuit and the excess power is absorbed by them. Originally these rheostats

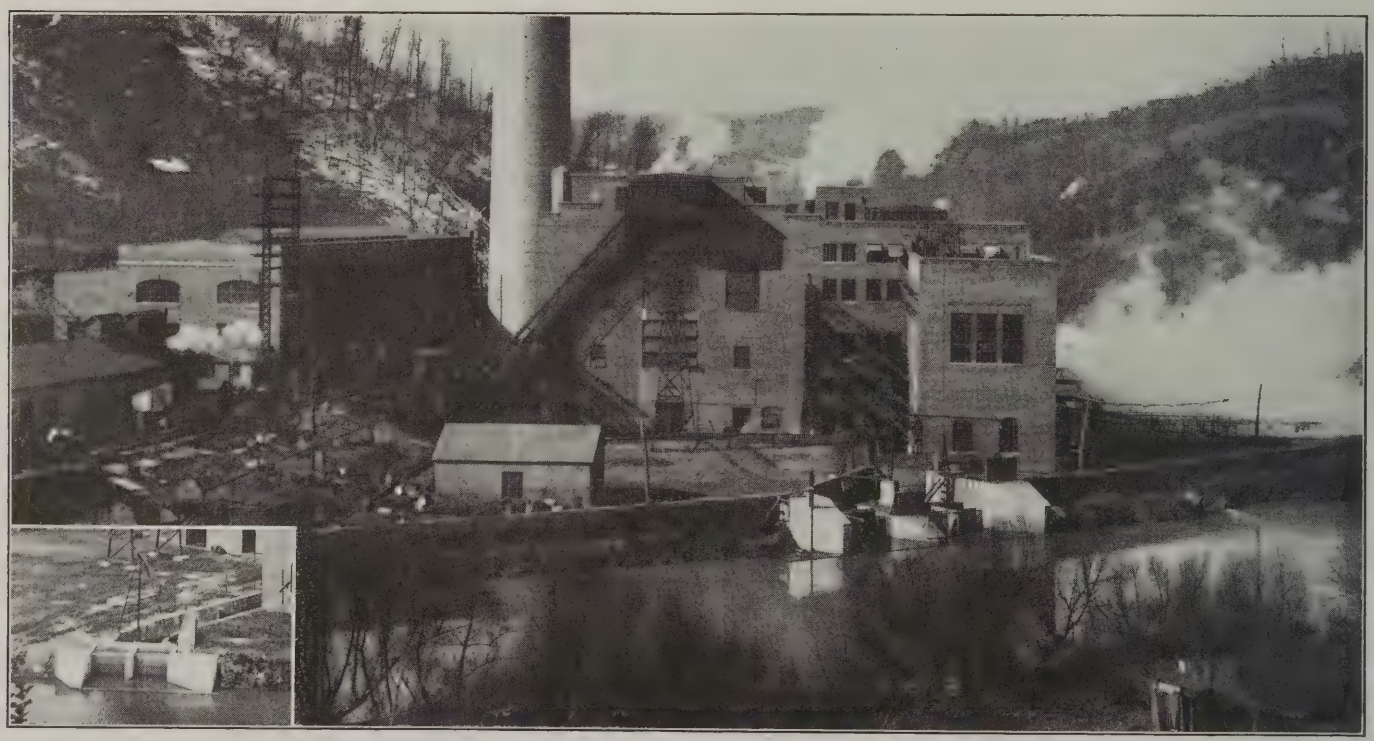

Fig. 6—The Power House As It Looks at Present. The Insert Shows the Intake Channel Entrance As Originally Built Without the Retaining Wall. The Steam at the Right Is Caused by the Spray Cooling System

were placed in the intake channel but their operation was not satisfactory because of the variation in conductivity of the water. They were taken out of the channel and placed in boxes on the other side of the power house, where water was supplied from the condensers. The new water rheostats are shown in Fig. 8. Their operation has been entirely satisfactory.

Overhead Maintenance

The 000 Phono electric contact wire is supported by a 00 solid copper secondary messenger which in turn is supported by a ½ in. stranded steel primary messenger. The greater part of the main line overhead is supported by a steel channel held up by tubular steel poles. (See Fig. 9.) In yards a built-up steel pole is used in connection with a cross catenary. The 44,000 volt transmission lines are carried on one of the steel poles.

A small car equipped with an elevating platform and an insulated ladder, known as the "hot ladder," were

Fig. 7—Device for Raising and Lowering Screens in the Water Intake Channel. One of the Screens is Shown Before Being Cleaned, Covered With Leaves

provided for trolley maintenance. Now the platform car is seldom used and practically all overhead maintenance work is done with the ladder. As the name suggests the "hot ladder" is used for working on the catenary when the circuit is live. It is made in three 13 ft. sections of carefully selected lumber. It is impregnated with insulating compound, is kept clean and dry and is treated about once a year with insulating varnish. Occasionally when the primary messenger has been knocked down together with the contact wire and secondary messenger, the ladder has been sufficient for the work. In such a case the two ends of the messenger are pulled together with a block and tackle, which causes the tackle to be lifted up with the messenger. The ladder is then leaned against the tackle until the messenger is connected.

As first installed a certain percentage of the auxiliary messenger was steel and the balance was copper. The action of the gases from the steam locomotives caused the steel wire to rust badly and it is gradually being replaced with 00 solid copper wire. This change will practically double the current carrying capacity of the overhead wires where iron was used as the secondary messenger.

A megger is used for testing insulators. If the test

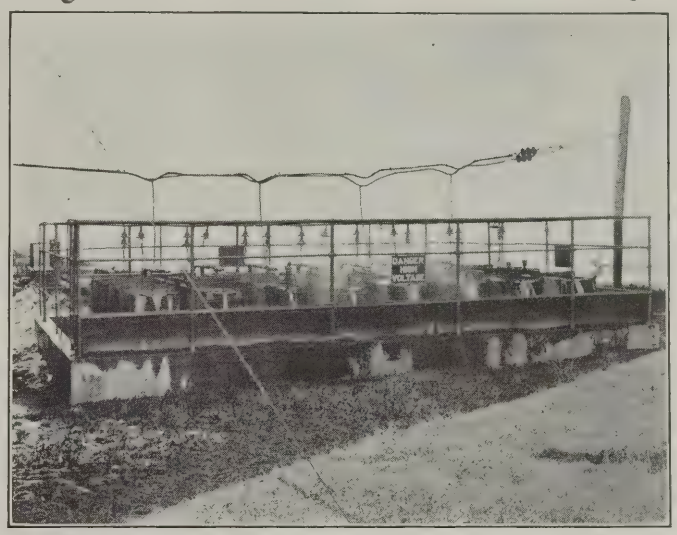

Fig. 8—The Water Rheostats for Absorbing Excess Regenerated Power. Water from the Condensers Flows Through Them Continuously

shows a resistance of less than 2,000 megohms, the insulator is replaced. It is then taken back to the shop, where cleaning may or may not bring the resistance, as measured by the megger, back to infinity. Wood pull-off insulators when taken down are dried out in the shop and revarnished.

In bonding the track originally, two 00 pin type, copper wire bonds were installed per joint, but in replace-

Fig. 9—Typical Main Line Overhead Construction

ment only one bond is put in. This maintains satisfactory continuity and the slight loss in conductivity is unimportant with 11,000 volt current distribution. The bond maintenance has been kept down by this practice.

Sleet is not common in the southern part of West

Virginia but has to be contended with occasionally. When there is sleet on the contact wire four pantagraphs are put up on the locomotives instead of the usual two. During sleet conditions as shown in Fig. 10 there was an insulator flash-over caused by a tree limb being blown over a trolley insulator. This slightly interfered with traffic, but aside from this, and occasional arcing at the pantagraph shoe, the sleet caused no trouble.

The wear on the contact wire has been measured and found to be between three and four thousandths of an inch per year on the main line. On branches and stub-end yard tracks it has been somewhat higher.

Locomotive Maintenance

The locomotives have two cabs and four trucks. Trucks and cabs are interchangeable and number plates are carried in slots so they can be transferred from one cab to another. Each cab has a transformer and a rotary phase converter and each truck is equipped with two three phase induction motors geared to a jack shaft which in turn is connected by side rods to the two pairs of driving wheels on the truck. The blower and a starting motor are mounted on the phase converter shaft and the air pump is connected to the same shaft by a flexible shaft and an automatically operated multiple disc clutch.

Secondary motor resistance for starting is provided for by water rheostats. The position of the rheostat electrodes is fixed and the resistance is changed by varying the height of the electrolyte. The electrolyte is water containing a little sodium carbonate. A motor

Fig. 10—The Bluefield Yard. The Sleet Conditions Shown Did Not Interrupt Traffic

driven circulating pump pumps water into the rheostats continuously and the height of the liquid is varied by moving the outlet up and down. The outlet consists of a hollow cylinder which is moved up and down by magnet controlled air cylinders through a gland in the bottom of the rheostats.

Maintaining the locomotives has at times taxed the ingenuity of all concerned. Frames have broken, been repaired and finally a new design of frame has supplanted the old. About half of the locomotives have been equipped with the new frames. The first was installed early in 1920 and as yet none have failed. Crank pins and side rod suffered a similar fate, but the result of the repair and replacement has been highly satisfactory. Chattering wheel slip at first added much to the wear and tear on the locomotives, but it is now the exception rather than the rule.

Several other changes made in the locomotives are of general interest. For example, split babbitted bearings were used as main motor bearings, but were found unsatisfactory because of alinement difficulties and because of throwing oil, some of which would get into the motor windings. It was also necessary to provide drip pans under the gears to keep oil off the track. Solid bearings with bronze inserts are replacing the split bearings. The solid bearings throw very little oil, do not show the tendency to run hot that the split bearings did and the

Fig. 11—One of the Electric Locomotives. The Picture Was Taken Before the Headlights Were Changed

bronze inserts are designed to prevent the motors from dropping down on the pole pieces in case the babbitt should flow.

There is a pinion on each end of each motor shaft. At first one of these pinions was shrunk and keyed to the shaft, the other being shrunk only. Now they are both shrunk on to the tapered ends of the shaft. After one pinion is applied its teeth are pressed tightly against the gear teeth which it meshes with by turning the motor as far as possible in one direction or the other. When the other pinion is applied it is turned as far as possible in the same direction so that in operation each pinion will take its share of the load. The faces of the first pinions were flat and flush with the ends of the pinion teeth. One of the new pinions is shown in Fig. 13. The extended hub in front is threaded so that a puller for taking the pinions off the shaft can be used. The extended cup at the back, which is the inner end of the pinion as applied to the locomotive, is grooved for the purpose of throwing off oil from the bearing so that the oil which creeps along the shaft will be thrown back into the bearing well. It also forms a pocket for the thrust collars, used to take up and limit the end play of motor rotor shafts.

The device shown in Fig. 13 is a transformer for heating motor pinions. The core lying in front of the pinions is slipped through the pinion and placed between the two vertical magnets. The core completes the magnetic circuit of the transformer and the pinion acts as a short circuited secondary winding. When alternating

current is applied to the primary coils a heavy current flows through the pinion. When it is heated to 180 deg. C. according to a mercury thermometer, the pinion is applied to the motor shaft. When the transformer is cold about 20 minutes is required to heat the pinion to 180 deg. The second pinion can be heated in 10 minutes.

Iron collector rings were at first provided for the main motors, but, seemingly due to vibration, they pitted and wore the brushes badly. Copper rings were substituted which have given satisfaction, many of them having the glossy chocolate brown finish considered ideal for commutators.

Several changes have been made on the water rheostats. Small particles of metal from the electrodes caused the outlet cylinders to stick in the gland. This was corrected by making a new gland with a collar which extended upward from the bottom of the rheostat tank for several inches into the liquid. The longest electrodes were also reinforced and the level of the liquid not

Fig. 12—Interior of the Locomotive Repair Shop at Bluestone

allowed to get below the bottom of the plates. Originally the center electrodes could be lifted out of the rheostat tank while grounded electrode remained in the tank. This permitted a variation of distance between electrodes when assembled. The ground plates are now made integral with, and lift out with the others. Current limit relays have been applied to prevent the outlet cylinders rising too rapidly and thereby overloading the motors and slipping the wheels.

Headlights were removed from the top of the cab where they were close to the pantagraph and placed on the forward and rear trucks.

A small storage battery is used on the locomotive in connection with the low voltage circuit used for lighting and control circuits. A generator driven by a small induction motor was used to charge the battery and supply power to the circuit. Occasional trouble with this motor caused the generator to drive the motor and exhaust the storage battery before the difficulty was discovered. The generator is now belt driven from the converter shaft and a small charge and discharge meter such as used on an automobile dashboard is installed in the engineer's cab.

A number of minor changes have been made to provide for better accessibility, better lubrication and for wear of certain parts.

The firemen or helpers as they are called say they consider the electrics simpler than steam locomotives. Inquiry into this statement brings out the explanations for this statement. Except in very few cases trouble or faulty operation of any part of the locomotive can be located and remedied by the helper. Even if a motor should burn out it can be cut out and the locomotive operated with three of the four trucks. Under these circumstances of course it may be necessary to reduce the tonnage.

The outstanding and pertinent facts are that a new type of locomotive was made to perform a service never before performed and was put into this service practically without experiment. Difficulties have been surmounted as they appeared and at no time have the electric locomotives been unable to handle the business that came over the division. Electric operation has made it possible to handle the ever-increasing traffic that is originated on this division. The far sighted policy of adopting it has been profitable to the Norfolk & Western, and the working out of the problems involved has been a service to all other roads confronted with similar problems.

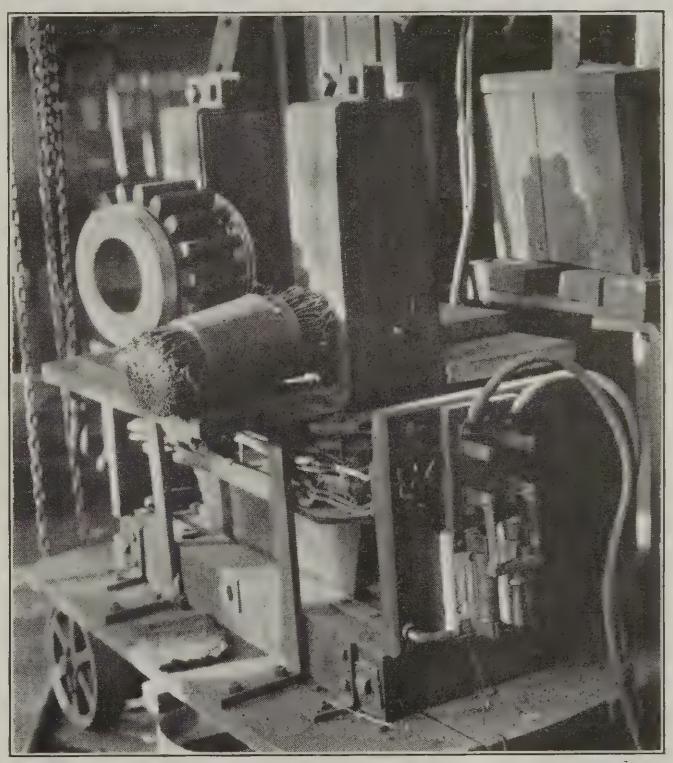

Fig. 13—One of the New Motor Pinions and the Special Transformer Used for Heating the Pinions

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Lessons in Railroading

Picking her way daintily through the locomotive plant, a young woman visitor viewed the huge operations with awe. Finally, she turned to a young man who was showing her through and asked:

"What is that big thing over there?"

"That's a locomotive-boiler," he replied. She puckered her brows.

"And what do they boil locomotives for?"

"To make the locomotive tender," and the young man from the office never smiled.—*The Overhere Digest (Minneapolis)*.

Foreign Electrification Notes

Brazil

THE most prominent electrification project now actually under way is the Paulista Railway in Brazil. When completed this line will require eight 100-ton freight and four 120-ton passenger locomotives. These are designed for operation on a 3,000-volt overhead trolley system with regenerative braking features for heavy grade service. Power will be purchased from the Sao Paulo Light & Power Co., at 88,000 volts, 60 cycles, generated principally in water power plants. The work on the line, which is 28 miles long, will be compleetd about June, 1921.

Reports received from Rio de Janeiro indicate that electrification of the government-owned Central Railway of Brazil will be begun soon. The commencement of the undertaking has been authorized by a bill recently passed by Congress.

The first step contemplates electrification of numerous suburban lines out of Rio de Janeiro and lines running into Sao Paulo. An expenditure of $10,000,000 has been authorized, $500,000 having been appropriated about a year ago by the Brazilian Congress for an extensive survey. The commencement of this work will mark the beginning of one of the greatest electrification projects.

Chili

The Chilean government is considering electrification of the Trans-Andean Railway between Santiago and Valparaiso. It is understood that the arrangements for financing this project are nearing completion.

Argentine

The American Embassy in Argentine reports that the minister of works is causing a study to be made of the Central Norte Argentino Railway with a view to its electrification from Cordoba to Cruz del Eje, a distance of 93 miles. This part of the line has a heavy passenger traffic and is favorably situated for hydro-electric power.

Japan

The completion of the extensive power systems along the Shinano river in Japan will make possible the electrification of over four hundred additional miles of Japan's State Railways. Electrified lines have already proved successful in Japan. The plan for widening the gage which had been contemplated has been dropped in view of the fact that the nation's supply of coal will be exhausted before many years unless electrification is begun. Although the bill calling for the expenditure of 100,000,000 yen on this project failed by a narrow margin to pass the Diet when it was proposed last July, railroad officers anticipate that the measure will receive government approval in this or in another form in the near future.

Lines operating in the vicinity of Tokyo for the year ending March 31, 1920, show a total car mileage of 9,816,211 and a power consumption of 24,795,646 kw. hrs. The coal used was estimated at 25,000 tons and the saving due to electrification at 50,000 tons.

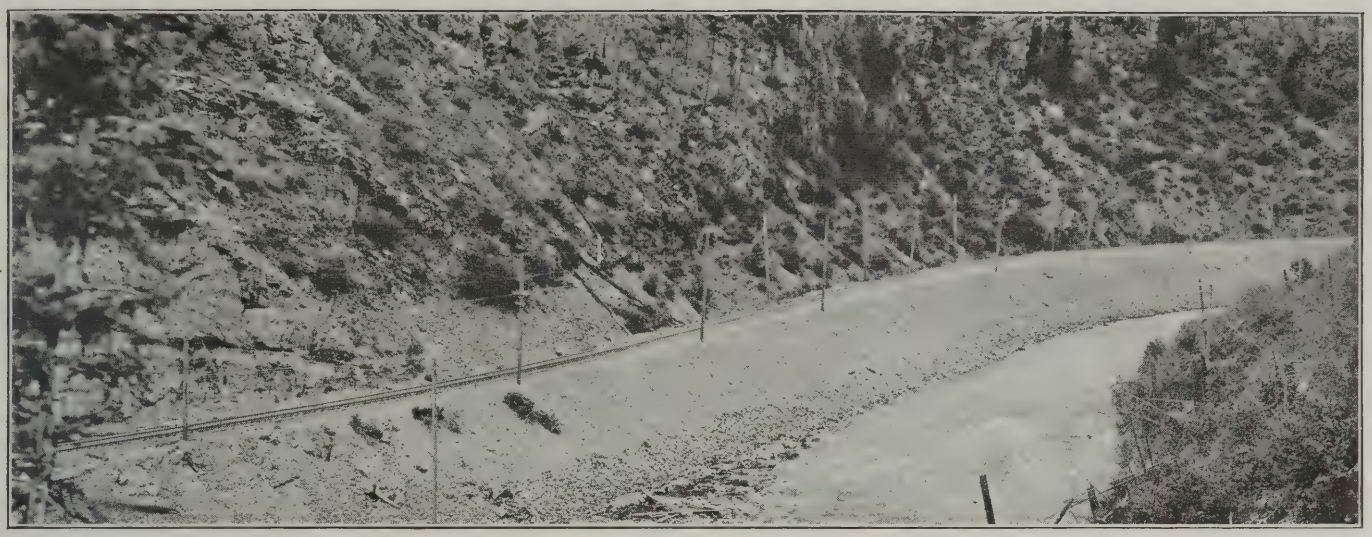
France

The Midi Railway is considering electrifying the following main lines: Toulouse to Tarbes, Pau, Bayonnes, about 220 miles; and Bordeaux to Dax, Hendaye, about 160 miles. Branch lines to be electrified are: Toulouse to Auch, 60 miles; and Montrejeau in Bagneres-de-Luchon 24 miles. If the full plans of the chief engineer of the Midi Railway are carried out, about 1,000 miles of main and branch lines will be electrified between 1920 and 1925. The necessary power will be obtained from the Pyrenees, partly from two stations at Soulom and Eget, in the Hautes-Pyrenees, which are already working, and partly from three new stations in the valley of Ossau, Basses-Pyrenees. Between 1925 and 1930 two further groups of lines will be electrified. The first group, comprising 370 miles, will be supplied by two existing power stations at La Cassagne and Fontpedrouse, in the valley of Tet (Pyrenees-Orientales) by three new stations in the same valley—Olette, Fontpedrouse and Les Bouillouses—and by three new stations in the valley of the Ariege—Ax-les-Thermes, Merens and Saillans. The second group, consisting of 370 miles, will be supplied by seven power stations which are to be constructed in the Cevennes.

General

It is estimated that there are about 1,300 electric locomotives in daily operation in all parts of the world. With the exception of the United States, the countries of Japan, Norway, Switzerland and Chili lead in electrification progress. Switzerland is electrifying 2,000 miles of track according to fixed schedule. France will electrify about 250 miles a year in the future. In the United States there are now 700 locomotives operating over approximately 8,000 miles of single track.

Unloading American Locomotives in Belgium



Along the Right of Way of the Chicago, Milwaukee & St. Paul

Train Handling With Electric Locomotives

Passenger Service and Passenger Train Operation —This Is the First of a Series of Three Articles

By W. S. H. Hamilton*

PASSENGER trains are run on a schedule which allows a certain running time over a division. This running time is based mainly on the average speed the motive power can make without too great an effort, the nature of the track and the country through which it runs. These last two items are especially important in mountain railroading. It is usually possible in reasonably good weather to make faster time than that called for by the running time without exceeding the limits of safety or comfort to passengers and this allows more or less time to be made up. The requirements then for the motive power for passenger service are ability to handle certain train weights over a given profile at the speeds required by the schedule efficiently and smoothly, maintaining quite closely the schedule speeds at all times with the trains on time and with them late, to handle them on all parts of the run at the maximum speed permitted by the safety and comfort of the passengers in order that the maximum amount of time may be made up. A large amount of time may be made up by taking advantage of the profile and holding the maximum permissible speed at all times and skillful engineers can make up considerably more time with the same motive power than unskilled or inexperienced ones simply by taking advantage of conditions.

ELECTRIC and steam locomotives have individual characteristics and the rules laid down for train handling with one do not apply to the other. Locomotives must be designed to fulfill the conditions imposed and used so as to handle trains effectively.

The three articles deal respectively with passenger car service and passenger train handling, freight service and freight train handling, and the use of helpers. The writer acted as an instructor to engineers on the locomotives of the St. Paul from December, 1915, to August, 1917, and from December, 1919, to April, 1920.

Electric locomotives for such service are shown in Figs. 1 and 2. The principal dimensions of the two locomotives are given in Table I. On the Chicago, Milwaukee & St. Paul there are five of the General Electric locomotives which at present are in service on the coast division and ten of the Westinghouse type handling the passenger trains on the Missoula and Rocky Mountain divisions. The original 42 G. E. locomotives are now used to haul freight on all three electrified divisions.

Locomotive Characteristics

The speed tractive effort curves on resistance when motoring for the gearless locomotive are shown on Figs. 4 and 5. It will be noted from them that there are a total of eight running speeds provided; four full field and four tapped field. The four full field speeds can be used anywhere including mountain grades (1.5% or over) but the four tapped field speeds only on lighter grades or with light trains on mountain grades. The

*Railway Equipment Department, General Electric Company.

highest full field speed is sufficient to take the maximum train up a grade at a speed slightly faster than the schedule speed and there is another running speed slightly lower which is about right for just making running time. The maximum speed up grade selected for electric locomotives is usually between 25 and 30 m. p. h. on mountain grades and is in excess of that which is made by steam engines when double heading.

In descending mountain grades regeneration is used to control the speed. Two connections of regeneration

TABLE I.

PRINCIPAL DIMENSIONS OF PASSENGER LOCOMOTIVES

	Westinghouse	General Electric
Wheel plan	4-6-2-2-6-4	2-4-8-8-4-2
Driving wheels, diameter	68 in.	44 in.
Truck wheels, diameter	36 in.	36 in.
Weight on drivers, in working order	345,000 lb.	492,000 lb.
Weight, total, in working order	562,000 lb.	551,000 lb.
Non-spring borne weight per driving axle	7,800 lb.	9,500 lb.
Length, over all	88 ft. 6 in.	76 ft. 0 in.
Total wheelbase	79 ft. 10 in.	67 ft. 0 in.
Maximum rigid wheelbase	16 ft. 9 in.	13 ft. 11 in.
Number of driving axles	6	12
Number of motors	12	12
Total tractive effort; 1-hr. motor rating.	66,000	46,000
Total hp., one-hour motor rating (contract)	4,000	3,240
Total hp., continuous (contract)	3,200	3,025

are available, one covering the range from 20-65 m.p.h., and the other from 10-30 m.p.h. The first connection is the one ordinarily used. The speeds permissible when descending mountain grades (1.5% and over) vary from 20 m.p.h. on grades having bad curves, rocks, etc., up to 35-40 m.p.h. for open straight track. The first limit is set by the ability to stop within a limited distance on account of vision and the second represents about the maximum speed from which the air brakes can be safely relied on to stop the trains. On lighter grades

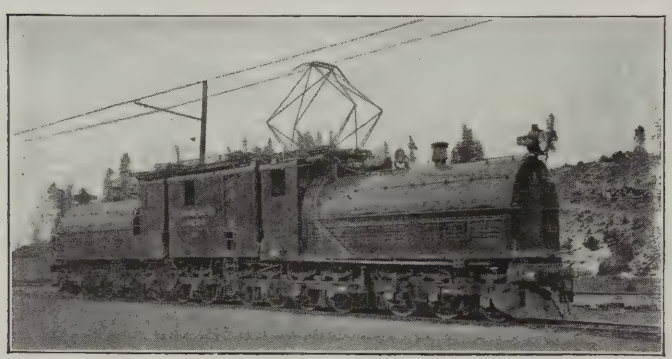


Fig. 1—The Bi-Polar Gearless Passenger Locomotive Built by the General Electric Company

higher speeds may be made but the maximum is usually 50-60 m.p.h.

Regenerative Braking

Regeneration saves the wear and tear on brakes, shoes, etc., and also the jar to the train caused by the repeated applications of the brakes. When operating with steam power on grades with numerous curves the trains are taken down by means of successive applications and releases of the air brakes, never making a very heavy application and only occasionally releasing them entirely. This results in a fairly even speed. On the heaviest grades this method cannot be used because of the tendency to gradually apply the brakes hardest on the cars at the rear of the train and put most of the work on those brake shoes. This is the reason for the occasional complete releases referred to above. They are usually made when the train is entirely in a curve or just entering one so that the train will not speed up too much while the brakes are entirely released.

The practice on the heaviest grades, particularly when nearly straight, is to allow the train to accelerate to the maximum speed, say 35-40 m.p.h., allowed on that grade, then a fairly heavy application of the brakes is made and the brakes are kept applied until the train slows down to about 15-20 m.p.h., when the brakes are entirely released and the train is allowed to run free until

Fig. 2—The Quill-Geared Passenger Locomotive Built by the Westinghouse Electric & Manufacturing Company

the maximum speed is again reached which gives time enough for recharging the brake pipe. This results in considerable jar to the train but makes the brakes on all cars apply uniformly. Retainers are not ordinarily used on passenger trains.

This jar is eliminated by the use of regeneration and the train may be held at a uniform speed. Within the capacity of the locomotive this speed may be varied to obtain the maximum desirable for any given part of the grade. This variable speed regeneration is especially desirable when handling train weights less than the maximum as then a wide range of speed can be obtained. Stops for cooling brake shoes and wheels are also eliminated which are required on some grades when operating with steam power.

Little Helper Service Required

The electric locomotive has a big advantage over steam power in that it is entirely feasible to build one big enough to go over the entire profile and thus eliminate helpers on the heaviest grades. This is best shown by the table below.

TABLE II.

HELPERS ON C. M. & ST. P. RAILWAY. STEAM OPERATION

Eastbound Passenger Trains.

Division	Helper Station	Helped trains to	Distance	Helpers ran to	Distance
Coast	Cedar Falls	Rockdale	19.2	Rockdale	19.2
Coast	Kittitas	Boylston	10.5	Beverly	29.3
Missoula	Avery	Roland	21.7	Haugan	37.8
Rocky Mountain	Butte Yard	Donald	14.9	Donald	14.9

Total miles electrified divisions	646.2
Total miles helpers required	66.3
Percentage of miles helper required to total miles electrified divisions.	10.2
Total helper district miles	101.2
Percentage of helper district miles to total miles electrified divisions	15.7

Note—With trains more than 10 cars or about 735 tons trailing, it was customary to provide helpers on the Coast Division from Renton or Maple Valley to Cedar Falls in addition to that shown. On the Rocky Mountain Division it was customary to double head the train over the entire division from Deer Lodge to Harlowton under this condition.

WESTBOUND PASSENGER TRAINS

Division	Helper station	Helped trains to	Distance	Helpers ran to	Distance
Rocky Mountain	Lennep	Loweth	9.7	Loweth	9.7
Rocky Mountain	Piedmont	Donald	20.7	Donald	20.7
Missoula	Avery	Haugan to E. Portal	14.1	Avery	37.8
Coast	Beverly	Boylston	18.8	Kittitas	29.3

Total miles electrified divisions	646.2
Total miles helpers required	63.3
Percentage of miles helper required to total miles electrified divisions.	9.8
Total helper district miles	97.5
Percentage of helper district miles to total miles electrified divisions	15.1

Note—The double heading on eastbound trains on the Rocky Mountain Division frequently required considerable double heading on the westbound trains in order to return the engines to the proper terminals.

With electric operation helpers are not used at all on the passenger trains. The locomotive shown in Fig. 1 weighs 265 tons and is capable of handling a 960-ton train, trailing (13 cars) on a maximum grade of 2.2 per cent. This permits it to operate on any grade between Harlowton and Seattle. The elimination of helpers saves considerable time previously required by stops and delays incident to cutting helpers in and out of the trains. Where helper districts form a considerable portion of the division it is certainly best to make the locomotive large enough to handle the train over the entire division alone.

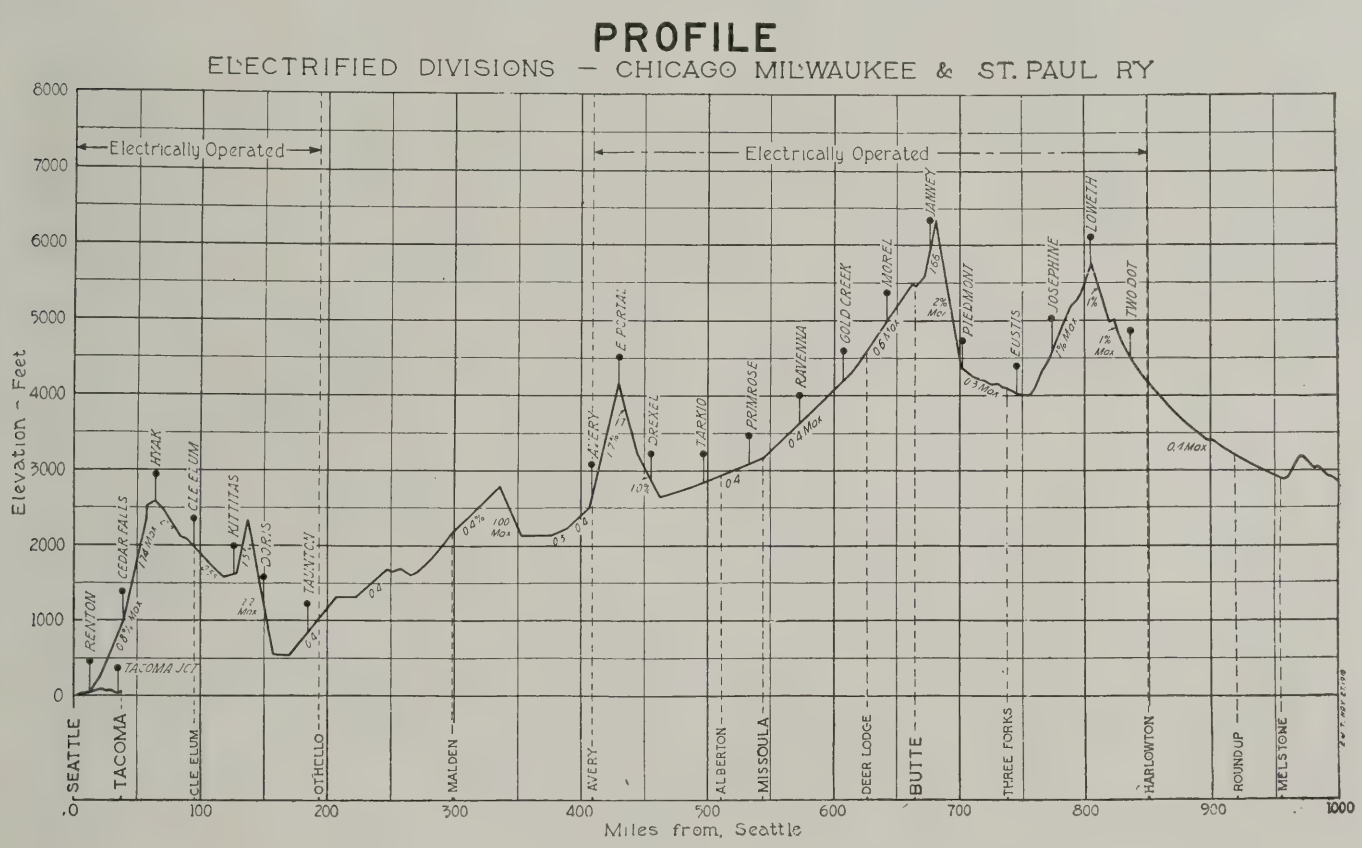


Fig. 3—Profile of the St. Paul, Including the Three Electrified Divisions

Metering and Air Brake Equipment Used

In order to make more clear the subsequent descriptions of the detailed handling of the trains it seems best to first describe briefly the metering and air brake equipment of the locomotives. This description applies to both passenger and freight locomotives. At each operating position in front of the engineer there is placed a panel on which are mounted two ammeters and the two air brake gages. One of these ammeters has the zero in the center of the scale and indicates to the right, the current being taken by one motor from the line when motoring and to the left the current delivered by one motor to the line when regenerating. It is called the line ammeter. The other ammeter is called the field ammeter, has zero at the left end of the scale and always indicates to the right. It indicates the current in the field of one motor and this is the same as the line current while motoring. A voltmeter indicating the trolley voltage and a speedometer are also furnished. The two gages for the air brakes are the same ones furnished on steam engines and show main reservoir, equalizing reservoir, brake cylinder and brake pipe pressures. The air brake equipment is known as the modified EL14 and consists essentially of two ET6 equipments operating together.

At each operating position two inter-connecting brake valves are provided, the automatic brake valve for controlling the automatic brakes on the train and locomotive and the independent brake valve controlling the brakes on the locomotive only, by which they may be applied and released regardless of the condition of the brakes on the train.

An electro-pneumatic valve is provided on the bipolar passenger locomotives which keeps the independent brakes released on the locomotive while it is regenerating. This prevents the application of both at the same time which is liable to slip the wheels. A pneumatically operated switch is also provided which cuts off all power when motoring or regenerating and also allows the independent brakes to apply, in case an emergency application of the automatic brakes is made either by the brake valve or from the train. These features are quite

valuable and are not installed on the older freight locomotives.

Passenger Train Handling

The handling of passenger trains is less complicated than that of heavy freight trains but a different kind of skill is required for each. The most important requisite is that the engineer must be able to judge braking distances correctly at various speeds when using the air brakes. The locomotive should have a reasonable number of steps in the control so that power may be applied gradually.

In starting a train on level or nearly level track the controller is simply pulled out notch by notch, the engineer meanwhile watching the ground until the train just starts to move, when it is usually pulled out more slowly until the locomotive has moved a few feet, after which the acceleration may be increased to the desired rate. This avoids any slack action or jolting of the rear cars due to the head ones being started too quickly. It is seldom necessary to take the slack when starting a passenger train with an electric locomotive as is usually the case with steam engines. When necessary it is usually caused by the condition of the rail being such that a high coefficient of adhesion cannot be obtained.

In stopping on the level or on light grades, the controller is shut off and an application of the air brakes made, the amount varying with conditions. Before coming to a stop it is customary to release partly or entirely the independent brakes. This allows the locomotive to stretch the slack out of the train, which permits starting again without any jolts to the rear cars.

Electric locomotives, especially those of the bipolar type, have much less friction than steam engines and this is very noticeable in handling passenger trains on light grades either ascending or descending. A steam engine when shut off at once shoves back against the train and tends to bunch the slack. When making slow downs for curves it is necessary to keep working a small amount of steam even while the brakes are applied on the train to prevent this action. With the electric locomotive this is no longer necessary as when power is shut off there is little or no tendency to bunch the train slack.

On grades of about .4 per cent maximum descending the electric locomotive will coast with the train very easily and seems to have about the same friction as the train. On grades of about .6 per cent maximum it is possible to regenerate a little. Steam engines on these grades would require working a small amount steam (drifting throttle).

Starting on Grades

When standing on mountain grades the train is held by keeping the independent brakes applied on the locomotive with brakes released on the train. When it is desired to start the train, the controller is pulled out two or three notches and the brakes released, the controller being then brought out notch by notch until the train either moves or the locomotive slips its wheels. An experienced engineer keeps close watch of the ground while doing this to see exactly when the train first starts, although he also manages to watch the ammeters so as not to apply too much current. As soon as the train has started moving the controller is held in that notch until the locomotive has moved a few feet and then the acceleration is continued at the desired rate. This is usually as close to the wheel slipping point as can be held.

In stopping on an ascending mountain grade the controller is eased off a couple of notches or so at a time until it reaches the second or third notch. With the controller in this position the train is allowed to "stall," the independent brakes are applied and the controller then shut off.

When taking siding on an ascending mountain grade the controller is shut off slowly to a notch in which the train will just keep moving. This allows the brakeman

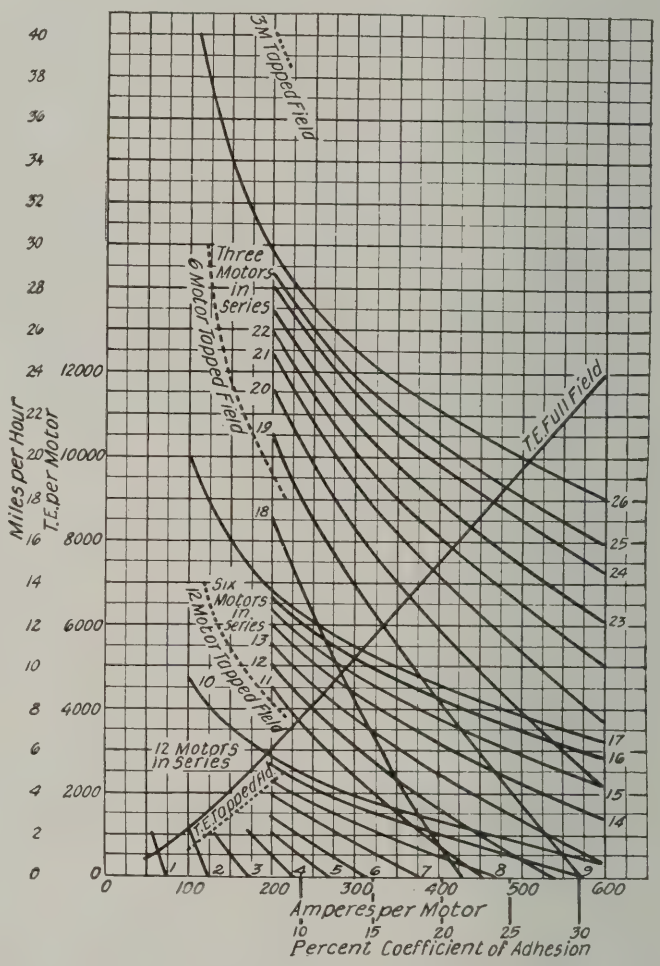


Fig. 4—Speed-Tractive Effort Curves on Resistance With 12, 6 and 3 Motors in Series for the Gearless Locomotive

to get off and run ahead to open the switch and allow the train to head in on the passing track without actually stopping. The train is then speeded up some by bringing the controller out a few notches but when the rear of the train is nearly over the switch it is necessary to move the controller back several notches again in order that the rear brakeman may get on after closing the switch without having to stop the train.

The Use of Regenerative Braking

During regeneration four of the motors on the gearless locomotive are used to excite the fields of the other eight which return energy to the line. A separate handle on the controller is used to control the regeneration and this is known as the braking handle to distinguish it from the main handle which controls the acceleration and motor grouping.

Two methods are provided for commencing regeneration. The first method permits of commencing regeneration without interrupting the motoring current entirely although reducing it in amount. This method is very desirable when tipping over the summit of a grade as then the locomotive passes over into regeneration very easily. Furthermore, some of the grades tip over very sharply and it is necessary to keep power applied to the train until it actually gets on the down grade and begins to speed up. This can be done very conveniently by this method.

The second method was intended for use when starting from rest on descending mountain grades. It allows regeneration to be commenced without any motoring current being applied first. When using this method the train is allowed to start from rest and run free until a speed of 5 to 10 m.p.h. is obtained, depending

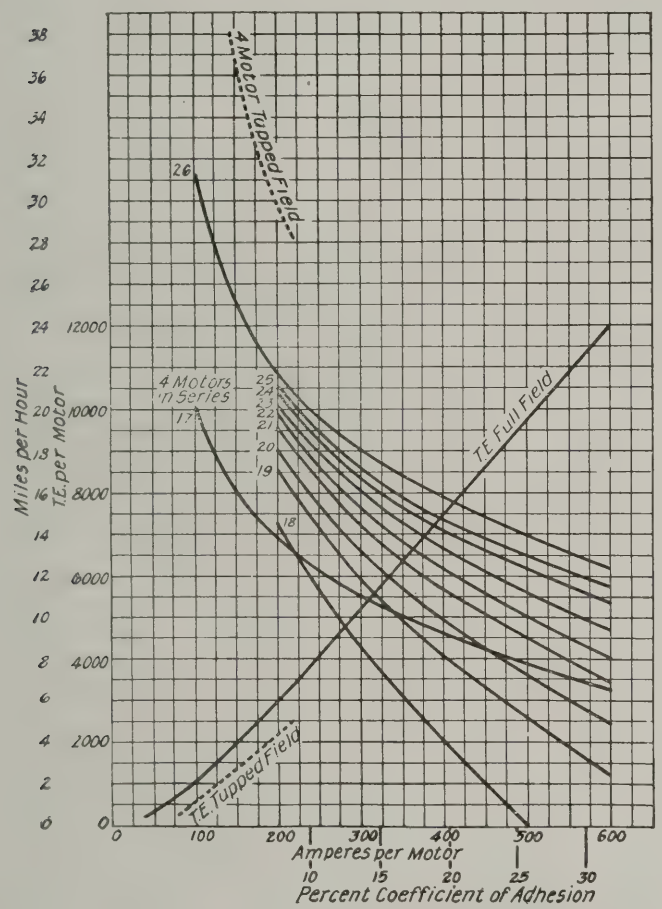


Fig. 5—Speed-Tractive Effort Curves on Resistance With 4 Motors in Series for the Gearless Locomotives

upon the grade, the independent brakes on the locomotive being used to some extent to control this speed. Regenerative braking connections are then applied and after they have been fully established, the operation is the same as with the first method. Theoretically, this should allow better train handling than the first method since there is no motoring first to pull out the train slack.

Practically no difference was found by several months' experience and the first method is used almost entirely now. From this it may be concluded that any method of applying regeneration to a passenger train will be successful providing that there is not too much motoring at first. In passing it may be noted that in the older geared passenger locomotives supplied the C. M. & St. P. Railway, it was necessary to apply full motoring connections before regeneration could be commenced and these locomotives were very successful in service for several years. They were finally converted into freight locomotives by changing the gear ratio. This was done because at the time they were purchased it was considered desirable to have only one type of locomotive for both freight and passenger service and not to adopt a purely passenger type until more locomotives were required.

When descending a mountain grade, regenerating, if it is desired to stop, the regeneration is slightly decreased by moving the braking handle back one or more notches, the automatic brakes are applied with a light service application of about 10 lb. and when the line ammeter indicates that the current returned to the line is nearly zero both handles are shut off and the application of the automatic brakes continued to the desired degree to stop the train. The independent brakes apply on the locomotive as soon as the controllers are shut off. As soon as the train comes to rest the automatic brakes are released on the train and the independent air brakes applied on the locomotive to hold the train.

In starting again, the independent brakes are released and power applied to start the train. The controller is brought out to the position where regeneration can be commenced and regenerative braking connections established as previously outlined.

It is sometimes necessary when regenerating to make slow downs at a faster rate than the regeneration will make them. This is done by applying the automatic air brakes on the train, the independent brakes being kept released automatically. In case the speed should be reduced too much the locomotive will commence to motor and if this becomes objectionable in amount the controller is shut off until the brakes are released and full speed can be resumed. There is no difficulty in using the air brakes and regeneration at the same time.

Kind of Control Required

In order to meet the conditions of train handling as described above successfully, especially those for mountain grade operation, the control equipment of the locomotives must be so designed that power may be applied gradually both to prevent wheel slipping of the locomotive and also to prevent jolts to the train. This requires an ample number of steps of resistance and proper proportioning of the same. The accelerating curves on resistance are shown in Figs. 4 and 5. The increments of tractive effort between steps when accelerating to a maximum of 25 per cent coefficient of adhesion are about 22,000 lb. for the 12 motors. This is about the maximum increment between steps that should be applied to a passenger train. The change in coefficient of adhesion between steps is about 5 per cent, which represents somewhere near the maximum for this weight of locomotive which should be allowed if the wheels are not to slip too easily when going from one resistance step to the next.

Furthermore, if the train is to be handled smoothly the same steps should be obtained when turning off the controller as when turning on. This bars out arrangements such as used on some trolley cars where the power circuit is opened as soon as the controller is started back toward the off position.

Ample capacity should be provided in the rheostats. The above locomotive can be worked at 300 amperes corresponding to 14 per cent coefficient of adhesion for about 10 minutes or at 485 amperes corresponding to 25 per cent coefficient of adhesion for about five minutes without overheating the rheostats. These values represent approximately the capacity required for mountain grade service.

Electrifying Harbor Railway

THE electrification of the Montreal Harbor Railway terminal, at present steam operated and consisting of surface lines and a total trackage of 58 miles, situated between the Victoria Bridge and the Imperial Oil wharf, is now well in hand. It was recently stated by F. W. Cowie, chief engineer of the Port of Montreal, that about 42 miles of track will be in operation by spring. The remainder, about 16 miles of track, from section 19 westwards will not be electrified until later.

Electrification of the railway terminal was advocated for many years by W. G. Ross, president of the Harbor Commission, and it is largely due to his efforts that this undertaking is now successfully nearing consummation. Early in 1918 the Harbor Commission realized that traffic on the terminal railway was increasing so rapidly that to avoid congestion it was necessary to procure more steam locomotives or to electrify the system. With the latter idea in view, a number of important electrified freight terminals were visited, and conditions closely studied, with the idea of adopting the best system for the Montreal Harbor terminal.

It was found that electrification for freight yards and terminals was everywhere reported as being economical and satisfactory in every way, electric locomotives being considerably more efficient than steam locomotives, especially in the winter time. An electric locomotive was found to be capable of drawing heavier loads up steeper grades than one operated by steam. The elimination of the smoke and soot evils and the saving of coal were also important points to be considered. In view of the climatic conditions, and the successful operation of the Canadian National Railway Lines through the Mount Royal tunnel terminals, which have a 2,400-volt, direct current overhead system in use, a similar system was considered for the Montreal Harbor terminals.

Line Construction

Sufficient material to make a start was received in September, 1919, and a commencement was actually made on the twenty-second of that month, construction being carried on steadily throughout the winter months on the overhead line work, as well as the track.

The overhead catenary system is used, the cross-spans being supported by wooden poles of western cedar where development is not completed and by steel poles where permanent conditions exist, the latter being set in concrete well above the ground level.

The overhead system has been divided off into approximately half-mile sections, with a view of anchoring each half-mile independently, the anchor poles being heavily guyed in all directions. The messengers are composed of high strength steel strands, heavily galvanized to withstand the climatic conditions, and put up under heavy tension in order to have a predetermined sag between the pole spans, which is determined by a dynamometer. Feeders will be carried from the substation to the various sections of the line where sectionalizing switches will be installed to energize the different sections. The return current will be carried entirely by the rail system. All the rails have been bonded with a view of having a perfect return negative circuit to the power house. Cross-bonding and tie-in bonds have been installed at all switches, crossovers and points, to eliminate any possibility of interruption should alterations be found necessary to the track system.

Type of Locomotives

The electric locomotives will be the enclosed cab-type, 83-ton units with double end control of the 2,400-volt direct-current type, using a pantograph collector to gather the current from the trolley to the control equipment and motors. There will be two locomotives to start with and as the complete system is gradually put into operation the steam locomotives will be withdrawn and replaced with electric.

Sub-Station

The sub-station will be a double story building situated centrally with the traffic conditions. The structure is to be of reinforced cement and steel, with fancy light buff brick facings. The incoming lines from the power company will consist of two 3-phase, 11,000-volt, 60-cycle circuits. This will be transformed down and converted to 2,400 volts d. c. for the railway operation. The switchboards will consist of marble panels carrying the necessary instruments, circuit-breakers and switch gear necessary for the control of the high tension incoming lines, power and light transformers, motor generator sets and the storage battery. The latter will be used for operating the solenoids and motor controls, cell switches and emergency lighting.

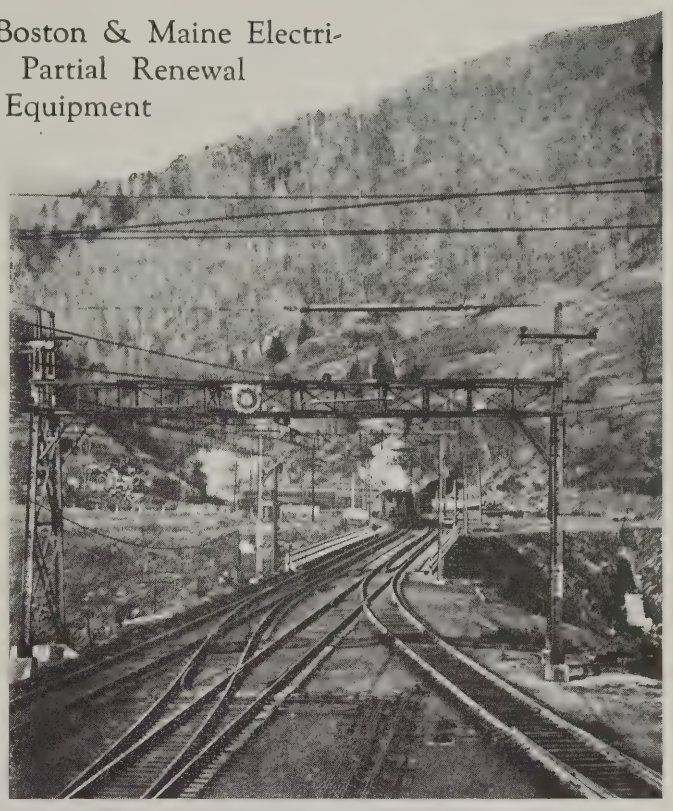
The work is being carried out under the supervision of F. W. Cowie, chief engineer of the port, while T. E. Salter is the electrical engineer in charge.

Photo from International

A Car Used as a Temporary Jail in a Prohibition Raid at Hurley, Wis.

New Catenary Construction for the Hoosac Tunnel

Severe Conditions of the Boston & Maine Electrification Necessitates Partial Renewal of Overhead Equipment



At the East End of the Hoosac Tunnel

IN order to fully appreciate the advantages which may be derived from tunnel electrification, one needs have an understanding of the conditions that obtained in the Hoosac tunnel of the Boston & Maine prior to the advent of electric locomotives on its line.

The Hoosac tunnel, which passes under the Hoosac range of the Taconic mountains in the northwestern corner of Massachusetts, is 4¾ miles in length, being the longest tunnel in the United States. Years ago the tunnel was equipped with electric lights and was featured in the advertising literature of the company. As time went on, the traffic through the tunnel increased and the quantity of smoke and gases emitted by locomotives passing through dimmed the electric lights until eventually they were abandoned. Each succeeding year brought increases in traffic with the conditions growing worse and worse.

The construction of the tunnel is such that there is a slight grade upward from each portal to the center. Normally there would be no necessity for a helping locomotive, but the rail conditions in the tunnel are so bad and so much trouble was experienced that helping locomotives were provided for trains in both directions. Now and then an engineman would attempt to go through the tunnel without assistance provided conditions were favorable, but for the most part the men were so affected by the difficulties of the run that they could not be induced to make the attempt alone. It must be said that their fears were justified, for on many occasions enginemen and trainmen were so overcome by smoke and gas as to require hospital treatment. So bad were the rail conditions, that it was quite a common thing for an engineman to hold a broom handle against the tunnel wall to ascertain whether or not his locomotive was moving. On one occasion, an engineman of a passenger train was so deceived by the sound of the exhaust and motion of the locomotive that he allowed the driving wheels to slip until he was signalled from an official on the train who had discovered that the train had stopped. The driving wheels had slipped so long that the head of the rails were practically worn through and the tires on all of the drivers loosened.

Having such conditions to contend with, the only surprising thing about the electrification of the Hoosac tunnel is that it was not done sooner. Even after the question of using electric motive power had been definitely decided upon, there still remained the difficult job of installing the overhead equipment under traffic. It is probable that only those who took part in this work can have any real appreciation of the difficulties encountered in its accomplishment. The rock men, who drilled the roof of the tunnel for the trolley supporting brackets, worked under the most adverse conditions. They wore large hats and goggles and before entering the tunnel rubbed grease paint on their faces. The work was performed in tent-like enclosures mounted on car roofs and a supply of air, as fresh as could be had, was pumped by compressors into the tent from the floor of the tunnel. The conductor of the train was in constant telephone communication with the train despatcher.

All of this was ten years ago. Today the tunnel is comparatively free from smoke. Certainly there are no such clouds of smoke and gases as were formerly found there. One can stand in the center of the tunnel and see the daylight at either portal, so great has been the improvement in conditions.

At a point halfway through the tunnel is located an air shaft which leads upward to the top of the mountain about 1,000 ft. above. At the top of this shaft a motor driven fan is installed for the purpose of clearing the tunnel of gases which are given off by the steam locomotives as they are being towed through. The arrangement of this fan is such that its direction of rotation can be reversed if desired. As it is normally operated the gases are drawn upward.

While there is of course no such quantity of gases and smoke as were present in former days, the total amount of injurious gases which is found to be present on account of the combustion of the coal in the steam locomotives has been sufficient to cause a considerable corrosion of the catenary construction. At the present time there are practically 100 movements through the tunnel a day, the traffic being approximately equivalent to 2,200 cars. It is fairly obvious,

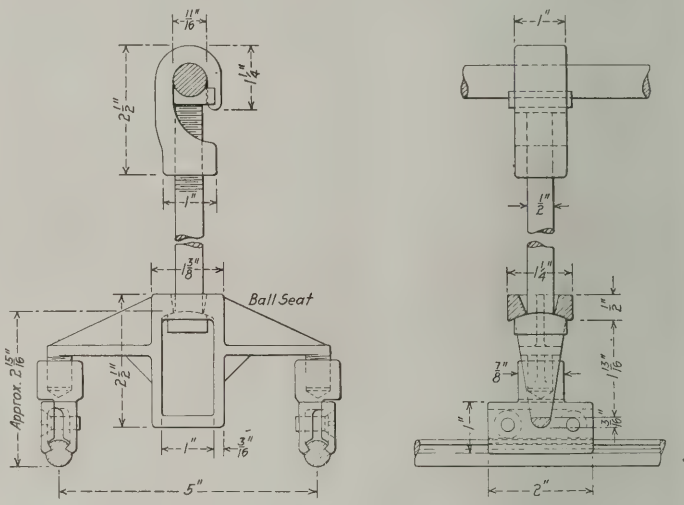
therefore, that with so many movements through the tunnel there would be a considerable amount of gas given off from the locomotives. This gas, together with the water dripping from the roof of the tunnel, has produced excessive corrosion on certain portions of the catenary construction, particularly noticeable on the bronze hangers which support the trolley wires from the stranded copper messenger cable above. In order to secure the advantage of better conductivity the hangers throughout the tunnel are constructed so as to support two separate trolley wires. A portion of one of these hangers is shown in the photograph where the corrosion is plainly evident. Short pieces of the trolley wire are also shown in the grip of the hanger clamps. The extent of the corrosion on this hanger is such that the clamp and the trolley wire have practically become one inseparable piece. The trolley wire used is figure 8 section Phono-electric wire and while the corrosion of the hangers is very marked the extent of the deterioration of the trolley wire is remarkably little. Originally the diameter from the top of this wire to the bottom was 0.5 in. After ten years of use this wire still measures from 0.387 to 0.443 in. in diameter, showing that so far as the wear from the pantagraphs is concerned, it would still have a number

A Portion of One of the Corroded Hangers From the Original Catenary Construction

of years to go before it would necessarily have to be renewed.

Strange as it may seem the determining factor in the renewal of the catenary construction was neither the Phono-electric trolley wire nor the bronze hangers, but was the copper messenger cable itself, and the circumstances under which this supporting conductor has failed are so extraordinary and unexplainable as to be of greatest interest to electrical men who have charge of similar installations in other localities.

From time to time during the past 10 years the messenger cable which was composed of 17 strands of hard drawn copper wire having a cross-sectional area of 300,000 circular mills, has failed in a most peculiar manner. Up to the present time there has been no satisfactory explanation as to the cause of this failure. The general appearance of the deteriorated parts is not unlike that produced by electrolysis, but inasmuch as this failure has consistently occurred between supporting insulators there is no foundation whatever upon which to base such a conclusion. Throughout the entire tunnel during the 10 years of its installation the messenger cable has deteriorated in some 40 or 50 places. These failing spots have been reinforced with other patches of the same kind of conductor using Crosby clamps. The general nature of the failure



Details of Trolley Hangers Used in Hoosac Tunnel

appears to be a reduction in the cross-section of the messenger cable with the eventual disintegration of the strands which compose it. When such weak points have been discovered and reinforced with patches the most peculiar and interesting factor is that the patches themselves failed in exactly the same spot as did the original messenger cable. Nor did the failures occur at all points where drippings from the roofs of the tunnel fell upon the messenger cable. Throughout its entire length there are many wet spots where the messenger cable is subjected to water dripping upon it but in many of these places no failures have resulted. From the facts at hand, it would almost seem that at certain points throughout the tunnel that the water dripping from the roof contained in suspension some chemical substance which possessed a property for attacking the copper messenger cable. Unfortunately no attempt was made to collect any of the drippings at these points on account of the difficulty involved in applying a suitable device for this purpose.

The failure of the messenger cable therefore was the chief factor which determined the life of the original installation. On account of the necessity of tieing up one of the tracks during the renewal of the overhead construction it was felt that it would be the best plan to not only renew the messenger cable itself but the hangers and trolley wires as well, as it would only be a matter of a few years when this would necessarily take place. During this reconstruction work it was found advisable to raise the height of the trolley wires from 2 to 6 in. according to the location.

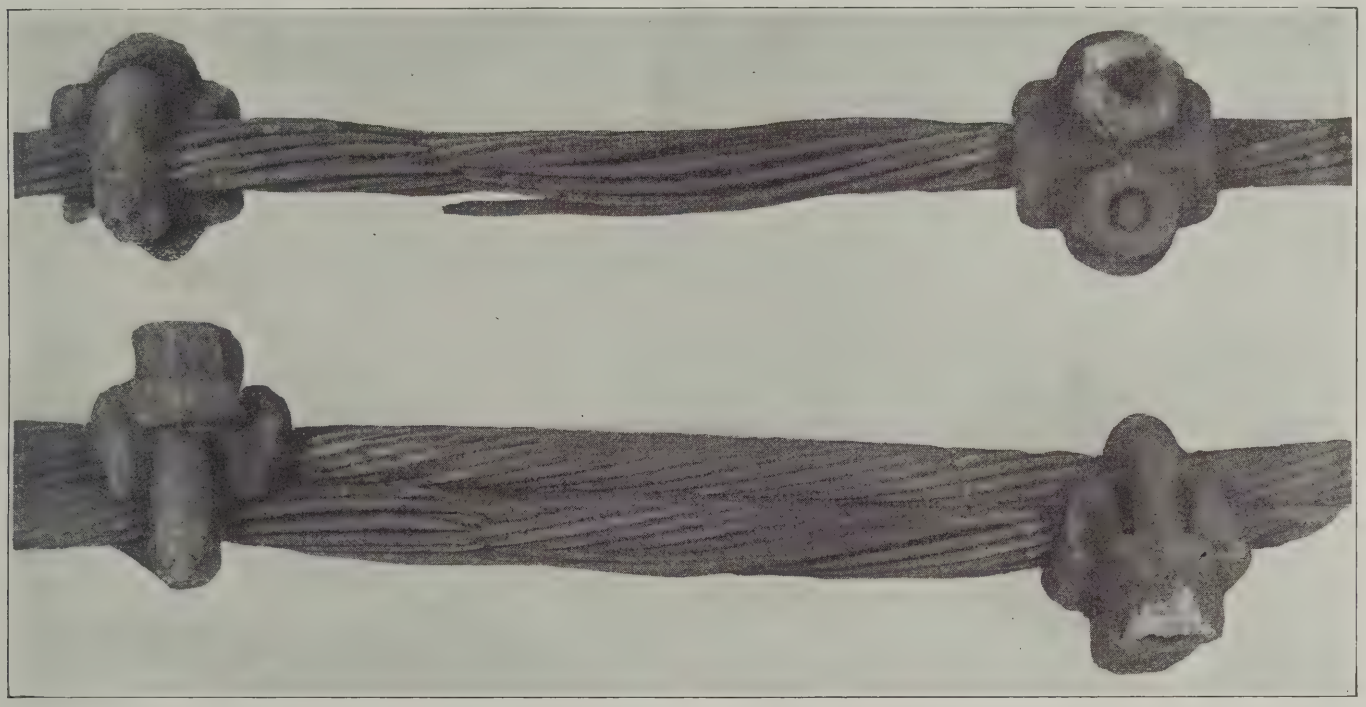
From time to time considerable trouble had been had on account of the brake staffs on certain box cars coming in contact with the trolley wires, and by providing additional clearance this difficulty would be eliminated.

The work of the renewal was begun on October 10 and completed on December 6.

The work of installing the new overhead construction was performed under vastly different conditions from those under which the original installation was made. There was practically no smoke to contend with and the amount of gases emitted from passing trains was kept down to a minimum by the action of the fan at the top of the central shaft.

In order to expedite the work a specially constructed work train was used consisting of a number of open cars upon each of which was erected a timber platform of such a height as to make it convenient for the men working on the catenary and trolley lines. The trolley through the tunnel is sectionalized so that either the eastbound or westbound track may be killed while the other side remains alive. During the reconstruction work the work-train occupied one of the tracks, the other track being used for traffic in both directions, train movements being made only upon train orders issued from the signal towers at either end of the tunnel. One of the cars of the work-train is equipped with a traveling ground consisting of a piece of iron pipe which is grounded to the rail and which travels along on the underside of the trolley in the same manner as the pantagraph. As a further protection the trolley was also grounded at the entrance of the tunnel.

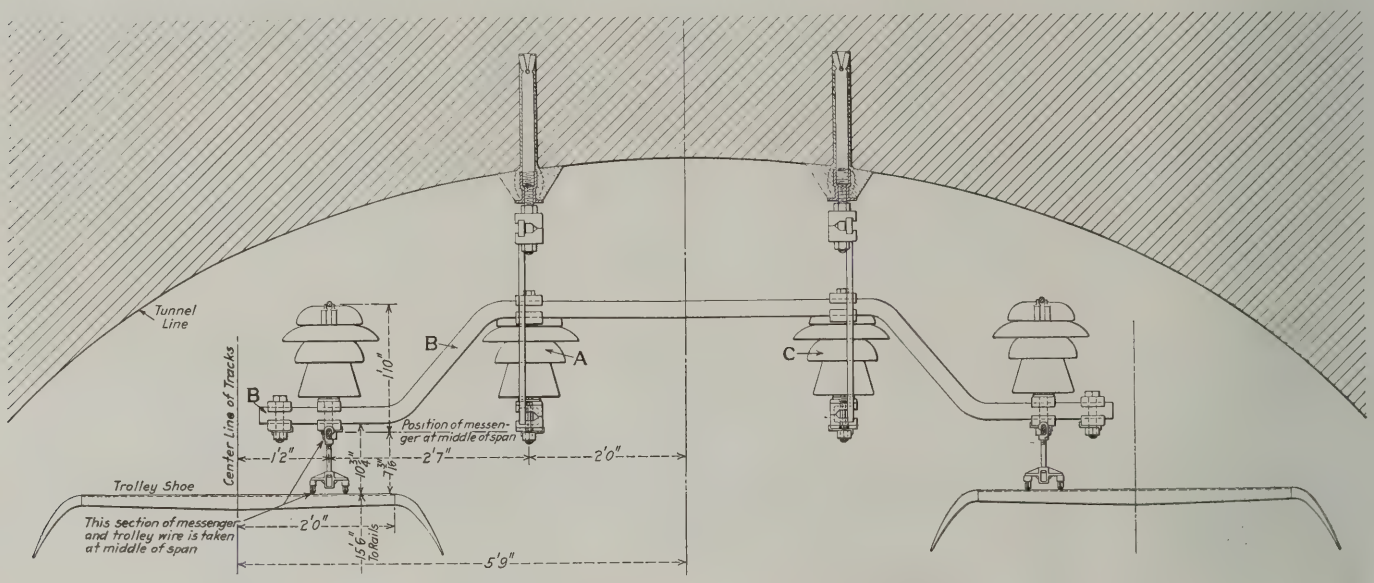
The new catenary messenger wire or cable differs from the original in that it is covered with a single braid of impregnated cotton. This cable was supplied by the Standard Underground Cable Company and the weatherproof braid with which it is surrounded is intended to prevent a re-occurrence of the same trouble which so shortened the life of the previous cable. Furthermore, the trolley hangers which are clamped firmly to this messenger wire are hooked over the outside of this braid, the only contact surface exposed being a small portion of the cable on the underside upon which the clamp presses. This unique construction detail has been adopted with the idea of preventing, if such a thing is possible, a re-occurrence of the trouble which was experienced with the former cable. In addition to the braid covering over the messenger cable a coating of black enameled paint has been applied. This paint not only has been used to further protect the messenger cable but has also been used on the hangers and the trolley wires as well. It is hoped, to some extent at least, it will eliminate the corrosion which was experienced with the first installation. Just how often it will be necessary to paint this cable, hangers and trolley wires is a matter of conjecture, but if it proves that the painting periods are not too frequent it is obvious that it will be far cheaper than to be obliged to renew the entire overhead equipment.



Peculiar Failure of Copper Messenger Cable. Upper Photograph Shows Top View of Cable and Lower Photograph Shows a Side View Take at the Same Point. It Will Be Seen that the Patch Shows Deterioration at the Same Spot as the Cable

The secondary objective in the renewal of the catenary construction, as has been mentioned before, was the raising of the trolley wires so as to obtain greater clearance between the wires and the brake staffs. At some points the trolley wires were raised 2 in., at other 4 in. and in a few instances as much as 6 in. The determining factor in this part of the work is the curvature of the roof of the tunnel, for it is obvious that as the trolley wires are raised the pantagraph horn will come closer to the rock surface of the tunnel. In some respect the raising of the trolley wire was perhaps the most difficult of all of the work done in the renewal of the catenary. The

same bracket supports both the live line as well as the dead one and greatest care had to be exercised when working upon the bracket. The work of raising the trolley was accomplished by first removing the pin of the secondary insulator, *A*, on the dead side of the line and then applying a jack at the end of the



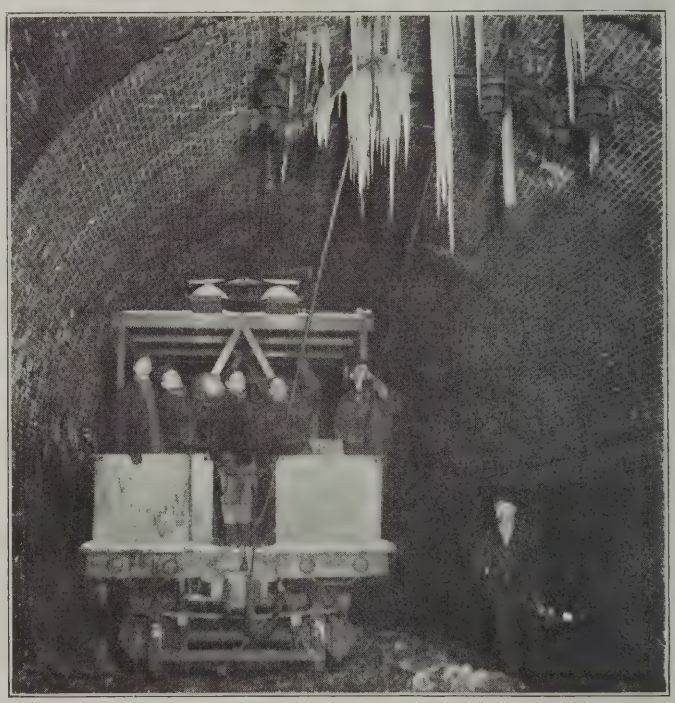
General Arrangement of Insulators and Brackets for Supporting the Catenary and Trolley Wire

cross bar *B*. Although the cross bar *B* is still held by the secondary insulator *C* on the live side of the line, the bar has sufficient flexibility to allow the insulator *A* to be raised 2 in. or more. The collars used for the purpose of raising the line are made of cast iron, some being 2 in. in height and others 4 in. After the collar has been put in place a longer insulator pin is used for the secondary insulator *A*; the bracket *B* thus being raised 2 in. higher raises the catenary messenger cable and the trolley wires the same distance. The danger to be guarded against with respect to the 11,000-volt pressure on the other side of the bracket is the case of a faulty insulator on the live side of the line. In this case a leaking current may creep across through the bracket, thus making alive the parts which are to be worked upon. Further protection was used in this connection by firmly grounding each bracket while the collars and new pins were being put into place. The increase in the height of the trolley wire was first made on one side of the tunnel throughout its entire length and then later the same methods were applied to the opposite line.

The final inspection of the tunnel was made on December 7, after all of the work had been completed. It was found on this trip that a number of points where the trolley wire had been raised the pantagraph came too close to the rock roof of the tunnel for safe clearance and these places had to be chipped away. An endeavor has been made to establish a minimum of at least 6 in. clearance between the horn of the pantagraph and the rock roof of the tunnel in all cases.

The insulators, both main line and secondary, as well as the bracket construction which was installed in 1911, are Westinghouse equipment. The iron parts have been kept well painted, with the result that practically no deterioration has taken place in the bracket proper. To all appearances the insulators seem to be capable of indefinite service, as it is only occasionally that any of them have given trouble. One of the difficultes which has to be met in the maintenance of the tunnel trolley is the removal of icicles which form in great masses on some of the brackets. In one of the photographs an inspection car is shown upon which the workmen are in the act of removing these icicles from the roof of the tunnel.

It must be remembered that the Hoosac tunnel was



Removing Icicle Formation From Suspension Brackets and Insulators

constructed many years ago. If it had been built in more recent times it probably would have been a concrete structure many of the difficulties would have been eliminated.

Bridge Construction—Train Leaving Tunnel

St. Clair Tunnel Operation Most Successful

Grand Trunk Electrical Installation Still in Good Condition After Twelve Years' Service

By R. L. Herman

SINGLE-PHASE electric locomotives were placed in service on the Grand Trunk in May, 1908, for the purpose of hauling freight and passenger trains through the St. Clair tunnel, under the St. Clair river, connecting Port Huron, Mich., and Sarnia, Ontario. The tunnel is a single track tube, 6,032 ft. in length, with approaches totaling 5.603 ft. The track enters the tunnel from the Michigan portal with a descent of two per cent for 1,914 ft., then graduates to 1.5 per cent for 1,718 ft. and then takes a two per cent grade for 2,400 ft. to the portal on the Canadian side. The locomotives haul trains of 1,000 tons up these two per cent grades at a speed of 10 miles per hour. The service rendered by both the power plant and the electric locomotive equipment has been such that during the entire 12 years of operation, delays of even a few minutes have been almost unknown. Some delays, due to insulator failure causing short-circuits, occurred at first, but this trouble has practically been eliminated by changing the design of some of these devices. The only trouble since these changes were introduced has been due to accidental injury.

There are six locomotive units, each weighing about 65 tons and mounted on a frame which is non-articulated from end to end. None of them have shown any signs of weakening. Each locomotive, consisting of two units, has a rating of 1,500 hp. and a maximum safe speed of 30 miles per hour. Each motor is directly connected through a single gear and pinion to a pair of 62 in. driving wheels. Considering that no quills or springs are used to absorb the shocks, the performance of the gears and pinions has been exceptionally good. A number of the original gears are still in service and in good condition after having made 432,000 miles. Some of the pinions have made more than 150,000 miles and are still in good condition.

Driving Wheels

At first, considerable trouble and expense was experienced with the wheels due to abnormal flange wear, which was caused to a large extent by the rigid wheelbase and the great number of curves and switches encountered. The mileage never exceeded 25,000 before it was necessary to remove the wheels for turning. In July, 1910, W. D. Hall, superintendent of the tunnel, conceived the idea of an atomizer to spray oil on the wheel flanges by means of compressed air. This is accomplished by pressing a button in either of the controllers, one of which is at each end of the cab. The oil is applied as the locomotive approaches a curve and then only for a very short duration of time. The results have been so remarkable that the tires of No. 9 pair of wheels of locomotive No. 2,658 have made a mileage slightly exceeding 300,000 miles since they were in a lathe.

It is found that the mixture of oil and air not only lubricates the flanges, but cleanses them from grit and sand. The lubricators are placed outside on the locomotive frame; the oil is thinned to suit the temperature conditions, so that it is sprayed nearly as well in winter as in summer. This device alone has naturally brought about a very considerable saving in both labor and tires. The electric locomotives on this property have been available for service more than 90 per cent of the time.

Pantagraphs, Autotransformers and Switch Groups

Each unit is equipped with one pneumatically-operated pantagraph which is controlled from the engineer's cab.

With a reasonable amount of attention these have given very little trouble. Breakages usually occur as a result of the shoe catching in some part of the overhead construction, but such trouble is rare.

The pantagraphs collect the current from a catenary overhead construction, supplemented with a steel contactor wire on the grades, at 3,300 volts, 25 cycles. The same voltage is used direct from the power plant, which is located near the portal of the tunnel on the Port Huron side.

After the current is collected, it passes to the auto-transformer, which is located on one side of the cab. During severe electrical storms two of these transformers were affected, but repairs were made without removing them from the locomotive. The cabs are roomy and all of the apparatus in them is readily accessible. The switch groups are located on the side of the cab opposite the transformer. The contacts in the switch groups require occasional scraping and the shunts are renewed from time to time, but all in all the smallness of the amount of burning is remarkable. The valve parts require little attention. An air compressor oil is used which does not cause gumming of the small parts.

The controllers are of the locomotive type, with short angular movement and the number of accelerating resistance steps provided give a very smooth acceleration without slipping the wheels. The controllers require little attention and have given practically no trouble.

Main Motor and Locomotive Auxiliaries

The field windings of the main motors have given no trouble at all but some armatures have been repaired from time to time. The commutators have made more

Grand Trunk Power House at Port Huron, Michigan

than 400,000 miles each and up to the present time not one has been renewed. Arrangements are now under way to start renewals, so that no trouble will be met in a year or two, due to the necessity of renewing a number of commutators at one time. Practically all the motors have made the same mileage and the wearing parts have held up very uniformly. Some of the commutators have exceeded 100,000 miles since last being turned and slotted. The brush mileage varies between 40,000 and 60,000 miles. No shunts or caps are used with the brushes, but the finger tips are practically the full width of the brush.

The air compressors have given satisfactory results. They are equipped with electrically controlled governor synchronizers, which cause both compressors to start and stop at the same time for double heading operation of the locomotives. The air compressor and blower motors have given splendid service. The latter have not required repairs to either the stator or rotor windings. Only three armatures of the former have been repaired, and one of these had the canvas heads renewed only. The commutators are cleaned from time to time, but it is not necessary to dress them in a lathe.

Power Plant

The two main units in the power plant are Westinghouse three-phase, 25-cycle, 3,300-volt turbo-generators. Operating in conjunction with these are two barometric

Detroit Edison Substation. This Building is Adjacent to the Grand Trunk Railroad Power House

condensers, two engine-driven exciters, one motor-driven exciter and two air pumps. In the turbine room basement are two engine-driven circulating pumps of the centrifugal type, one house pump, two engine-driven stoker fans, the transformer room, a store-room and a mercury arc rectifier. The boiler room contains four water tube boilers equipped with underfeed stokers, an independently fired superheater, overhead coal bunkers and two feed water pumps.

The insulation of the generator fields gave evidence of breaking down after about six years' operation, at which time they were rebuilt with more modern insulation. They have given splendid service since that time. The stator coils have not given any trouble whatever, although frequently subjected to severe strains.

The motor driven exciter unit has given excellent service. It has been in continuous operation, night and day, for 12 years with exception of a few minutes each week for inspection and dusting. The commutator of the direct-current generator has never been turned or dressed since being slotted about 11 years ago. During an electrical storm, one or two coils in the motor broke down, but were repaired in short order and the set put back in service.

The turbines have given very satisfactory service dur-

ing the 12 years. No bearing trouble has been experienced. In fact, the oil stone marks on the spindles are just about as fresh as when they were made 12 years ago. Some of the steel blading has been removed and as the small or high pressure blading was not laced it has been found advisable to replace the small unlaced steel blading with laced bronze blading. The turbines take the irregular loading without any noticeable vibration.

The condensers and circulating pumps have required the ordinary running repairs only. For a short period at the start, the condensers caused a little trouble due to the spray nozzles becoming clogged with small fish dur-

One of the Two-Unit Locomotives Used in the St. Clair Tunnel

ing certain seasons, as the water was taken directly from the St. Clair river. This was overcome by removing the grids from the nozzles, thus permitting the fish to go right through with the water.

The engines of the engine driven circulating pumps have received only the ordinary repairs and the pumps show practically no sign of wear. In fact the paint with which the impellers were originally painted is even now quite fresh.

The boiler feed pumps are of the reciprocating type. They have received frequent repacking and renewals of parts. Water for sealing the turbine glands and various parts is supplied by a house pump of the reciprocating type. In order to avoid trouble, due to loss of vacuum on account of failure of the water supply, the discharge pipe of the pump is connected with the city supply line, but interposed by a check valve. Hence, by maintaining a slightly higher pressure at the house pump than that of the city line, no water from the city system can pass. Should it be necessary to stop the house pump, or should it fail, the check valve will open and thus an uninterrupted supply of water is maintained. This little detail in itself is a good precaution which guards against an accident that might tie up the system and it is characteristic of the whole installation.

The boilers and stokers have given very satisfactory results, especially in view of the fact that they have had to care for very erratic load conditions. A few tubes have been renewed during the 12 years and the furnaces have been repaired from time to time. It is probable that it would not have been necessary to have renewed even these few tubes if slack coal could have been used at all times. On account of the very sudden demands for power it is necessary to use high air pressure, so that when crushed mine run is used a blow torch effect may be set up to such an extent as to result sometimes in the blistering of tubes.

Although working under widely fluctuating conditions of load, not one retort was burned out and not one renewed in a period of 11 years. At the end of this period all the retorts were renewed, because they were worn out by the action of the rams and corrosion, where they were set in the brickwork at the front end. The boilers and stokers have been in 24-hour service since November, 1901, and during that time have only been out of service for the brief intervals of their regular cleaning and inspection periods.

Trolley Line Construction

The trolley and messenger wires are supported on steel bridges, which are spaced at 250 ft. intervals. The trolley wire is suspended from the messenger wire by catenary hangers spaced every 13 ft. This type of construction has given very satisfactory results. The greatest wear was found at points of rigid support. At these points an iron trolley wire was installed beneath the copper, and this has given satisfaction, especially where it is not exposed to steam locomotive gases with the resultant deterioration.

Train delays due to line material failures have been so few as to make them almost negligible. Especially has this been true during the last six or seven years of op-

Interior View of Locomotive Cab

eration. During the first few years a few short circuits and consequent delays were experienced, due to insulator failures, which usually resulted from steam locomotive gases causing flashovers. Some failures were experienced due to the cracking of insulators, resulting from unequal expansion and contraction. These have been overcome by installing two insulators in series where locomotive gases have to be contended with. At first there was some insulator trouble in the tunnel due to unequal expansion and contraction, but this difficulty has been

overcome by installing insulating devices of newer design.

Another source of trouble due to short-circuits was brought about by birds alighting on the lightning arrester tips. As it would be a difficult matter to educate the birds, perches were provided above the arrester tips for the birds' convenience, and in this manner the trouble was easily overcome.

Detroit Edison Service

Arrangements have been completed with the Detroit Edison Company to supply power for the tunnel operation. A Westinghouse synchronous motor-generator set with a capacity of 2,860 kilowatts has been installed in the substation, which stands just north of the power house. The motor operates at 4,600 volts, 60 cycles, three-phase, and the generator furnishes single-phase, 25-cycle current at 3,300 volts to the tunnel trolley. The trainload reaches a four-to-six-minute peak of about 2,400 kilowatts. Both the motor and generator sides of

Electric Locomotive Entering the Tunnel

the machine have separate exciters at the respective ends of the shaft. Both exciters are equipped with automatic regulators. The motor exciter regulator takes care of the power-factor and the other regulator controls the generator voltage.

Results

The average cost of maintenance of the electric locomotive equipment, material and labor to December, 1914, was 4.514 cents per locomotive-mile, and from December, 1914, to December, 1919, 7.051 cents per locomotive-mile.

The fact that the electric locomotive equipment, the power plant equipment, and the line material are in splendid operating condition today, not only speaks well for both the design of the various parts and the quality of material used in their construction, but also for the maintenance and supervision given them during these twelve very successful years of operation.

A Flat Welding Electrode

It has been proposed by W. W. Palmer, electrical engineer, Quasi-Arc Weldtrode Company, that a flat electrode be used in the place of the usual round one. The flat electrode, he maintains, will do away with some of the manipulations necessary when a round electrode is used. For example, when a weld, as shown in Fig. 1, is to be made with a round electrode, the welder must perform four functions as follows: (1) feed the electrode into the arc at the same speed that it is melted; (2) move from plate to plate, with regular swing, as from a to b to c, etc., in order to fuse both parent members equally; (3) move the arc along the direction of the seam as the welding progresses and (4) dip the electrode toward the bottom of the V each time it crosses over, in order properly to fuse the bottom of the seam.

With a flat electrode the weld is started as shown in Fig. 2. The electrode is held in the position shown and the arc burns simultaneously completely across the face of the ribbon and on both parent plates. The electrode is not wiggled from place to place, but is set straight into the arc, and the arc is gradually led in the straight path shown by the arrow. It is maintained that the arc length or distance from the electrode to the work is constant at all points as the electrode gradually burns to fit the V.

This is explained as follows: if, through eccentric mani-

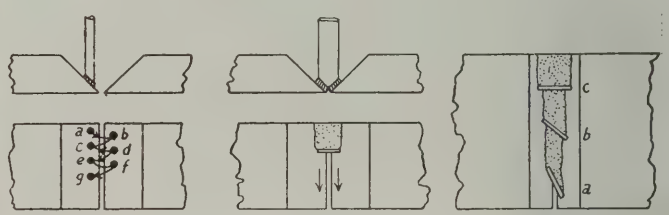


Fig. 1 Fig. 2 Fig. 3

pulation, or due to irregular surface of the work, the electrode should come closer to the work at one point than at others, the resistance of the current path at that point is reduced and the resultant rush of current at that point quickly fuses away the thin electrode and causes it to again fit the work. Only two motions are required in starting the weld, that of feeding in the electrode as it burns off and moving it along the work.

Where large round electrodes are used, lack of space sometimes makes it desirable to use two sizes of electrodes, the smaller size being used for the first few runs. This is held to be unnecessary in the case of the flat electrodes and it is used as shown in Fig. 3. The rod is moved straight down the seam as before, using it first in the position a and then b and c respectively.

It is expected that this type of electrode will soon be placed on the market.

Under the direction of Frederick D. Underwood, president of the Erie Railroad, a movement has been started to enroll in the American Legion every veteran in the employ of the railroad. E. H. Jeffries, formerly of the Third Division, in a visit to every State in which the Erie operates, will make an effort and seek to line up those of the Erie's 5,000 veterans who are not yet members of the Legion.

Train Entering the City of Montreal from the Mount Royal Tunnel

Electrical Operation on the Canadian National

Amalgamation of Canadian Northern with Government Railways Greatly Modifies Original Plans

THE Canadian Northern Railway System completed the electrification of its Montreal terminal in May, 1917. The original objective of the company was to secure an entrance into the city which at that time was only possible by means of a long tunnel under Mount Royal. It was planned that the line should run down to the harbor on the St. Lawrence River and that it should be used for the purpose of carrying carloads of grain directly to the vessels bound for Europe. The subsequent amalgamation of the Canadian Northern with the Canadian National system has held up this original plan from execution inasmuch as the freight traffic has been diverted to the harbor by other routes which became available after the consolidation was effected. In consequence of these changed conditions the electrified zone terminates at present at a passenger station on Lagauchetiere street, and the entire operation of the line is confined to passenger service.

In view of the enormous expense involved in the construction of the tunnel, which is three and one-third miles long, the cost of electrifying the nine-mile terminal zone becomes rather insignificant. Considering the changed conditions under which the road is now operating, as compared with those which were originally intended, it is evident it would be a long time before the traffic through the tunnel would justify the expense involved in its construction. It is more than likely, however, that the tunnel will form the main entrance to a joint terminal for all three amalgamated railways as soon as the Grand Trunk becomes a part of the system and eventually it will be of the utmost importance in making a satisfactory terminal in Montreal.

From an electrical point of view there are a number of features, relative to the installation of the work, as well as others in connection with the maintenance of the system, which are of interest. A portion of the distance at the entrance to the tunnel is comprised of two separate tubes constructed of concrete walls and roof. One of the tubes is shown in one of the illustrations. By far the greater portion of the tunnel under Mount Royal, however, is so constructed as to accommodate two standard tracks. The first trolley wire installed over one of the tracks was put into place by men working on flat cars moved by means of a steam locomotive. Sulphur fumes and coal smoke from the locomotive made the construction work decidedly unpleasant. Upon the completion of the first trolley line through the tunnel, however, a pantagraph arrangement projecting from the side of an electric locomotive, so as to come in contact with the wire already installed, was used to supply motive power for the construction of the second trolley line.

In view of the fact that the electrified zone at present is equipped solely for passenger business, the railroad company has assisted and encouraged a land company in promoting the growth of the town of Mount Royal, located at the western portal of the tunnel. In pursuing this plan some seventy-five or more dwelling houses of the better class have been constructed during the past year, and it is expected that this suburb will develop rapidly. The fact that the station of Mount Royal is but 11 minutes distant from the heart of Montreal will doubtless be one of the most important reasons why this section will become one of the city's most desirable suburbs.

About three and a half miles further west at Lazard, the electric zone terminates so far as the main line is concerned. From this point, trains traveling further west are coupled to steam locomotives.

Last October an extension of eight-tenths of a mile

was added to the electrified zone between Lazard and Cartierville. Cartierville, which lies to the north of Lazard, is a town of about 5,000 population and is situated on the Des Prairies river. The town is something of a summer resort and the comparatively small expense of extending the electrified line approximately eight-tenths of a mile from Lazard was thought to be justified.

For the most part the operation of the electrical equipment has been remarkably successful, practically no failures having resulted from the time of the installation in 1917 until last winter. The winter conditions during the winters of 1918 and 1919 were particularly severe on electric motors. Singularly enough one motor of each of the six locomotives purchased by the company failed, due to broken-down insulation and what was at first most puzzling was the fact that in each locomotive it was always the No. 1 motor that failed. Subsequently, it was found that other roads had experienced this same trouble under winter conditions and the trouble was traced to the fact that the No. 1 motor was exposed to the full potential of the line whereas the others were not. During the winter weather snow was blown or drawn into the motors in such a way that it worked its way under the commutator where it melted and eventually caused a ground to occur. Although all of the motors were more or less affected as a result of this snow condition, the No. 1 motor was the only one which received the full potential of the 2,400 volts from the line and therefore the point at which the trouble first became manifest. After some study a method was devised to

A Portion of the Tunnel Near the Entrance

overcome this trouble. The joint between the inside of the commutator and the winding was filled with a special tacky varnish which was applied from the interior and is continually being pressed further in on account of centrifugal force. It is also planned to apply the same treatment to multiple unit equipments which are expected to be put into service in the near future. As a further precaution in keeping the snow out of the locomotive motors the ventilating fans have been cut out of service. This can be readily done without damage to the equipment as the motors are seldom heavily loaded for long periods and the winter temperature is low enough to cool them without the ventilating fans.

Six locomotives, weighing 85 tons each, designed for a free running speed at 45 miles per hour, constituted the original purchase of motive power by the company for the operation of the electrified zone. The subsequent changes in traffic conditions, however, have been such that practically two locomotives are able to handle all of the traffic. All of the locomotives have been in service, however, some of them making many more miles than the others. The mileage records of the six locomotives between May, 1917, and October, 1920, are as follows:

Swinging Pantagraph Attached to the Side of Electric Locomotive Made Possible the Installation of the Second Trolley Without the Smoke Nuisance of a Steam Locomotive.

Locomotive 9100—44,000 miles.
Locomotive 9101—38,000 miles.
Locomotive 9102—20,000 miles.
Locomotive 9103—57,000 miles.
Locomotive 9104—30,000 miles.
Locomotive 9105—13,000 miles.

These records of mileage were taken by two speedometers, one for each direction, which are placed on each locomotive, the readings of the two being added together to obtain the total. The estimated cost of maintenance of locomotives on a mileage basis over the whole period is about seven cents per mile; this includes simply locomotive repairs and labor of three men in repair shop. Had the traffic been heavier and more of the equipment in service it is reasonable to assume that the maintenance cost per mile would have been lower still.

Although multiple unit car operation was planned originally there have been no multiple unit cars in operation up to the present time. The traffic is entirely handled by means of ordinary passenger coaches hauled by an electric locomotive. Multiple unit equipments or rather motors for multiple unit cars have been purchased and are available for installation in cars whenever traffic conditions seem to warrant any extension of service.

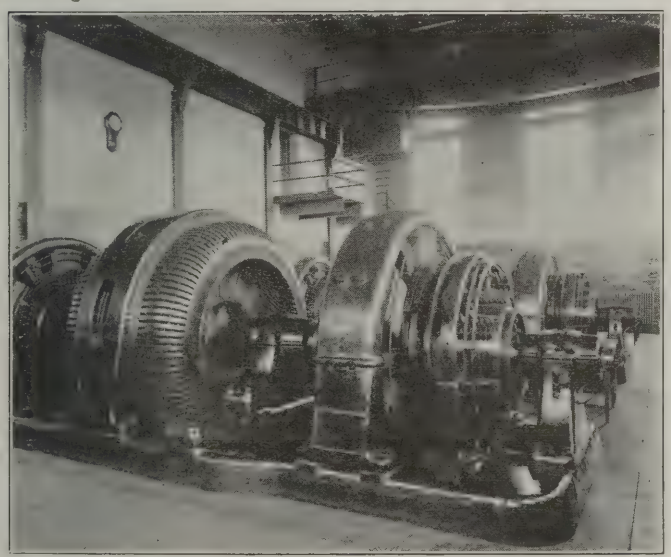
The repair shop of the line is located about one-half

mile west of Lazard. A small force is employed consisting of a locomotive repair man, two helpers and on occasion part time of a blacksmith from the mechanical department. This force has been able to keep the locomotive equipment in first-class repair. The shop is comparatively small and the equipment consists of three engine lathes, a pipe threader, a shaper, a grinder, hack saw and a band saw. All of these machine tools are

Locomotive and Coach Used for Local Passenger Service

operated from a line shaft with belting driven by a 15-hp., three-phase, 60-cycle, 550-volt induction motor. In addition to these tools a drill press is individually driven by a 5-hp. motor, 550-volts, three-phase, 60 cycles.

The shop is equipped with a traveling crane of approximately 7 tons capacity, having been cut down in

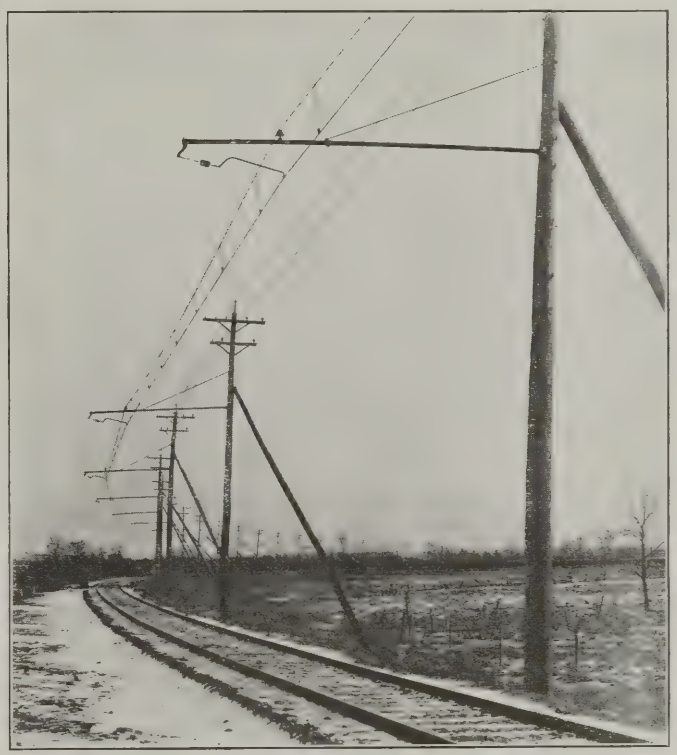


Interior of Substation at the West Postal

length from a 5-ton crane. It is used for lifting pantagraphs, motors and auxiliary apparatus. There is no drop pit at Lazard; whenever it is necessary to remove wheels for reflanging, or for any other purpose, the locomotive frames must be blocked up with a cribwork of timbers. Were this frequently required it would be rather an expensive operation, but since the traffic is light and two locomotives are sufficient to handle all of it, there is ample time for wheel repairs in the manner indicated.

Until this year no attempt has been made to bond any of the track, the splicing bars having been considered sufficient to carry the return current back to the sub-station. While the rail joints have apparently performed this function more or less successfully the burning off of a water pipe in the vicinity of the sub-station at the time a short circuit occurred on the line, gives evidence that this manner of handling the return current is not wholly satisfactory. This particular trouble is not liable to occur again as each rail joint is now protected by a weld bond.

The pole line used for the suspension of the catenary as well as for the transmission system is of wood construction. Prior to being put into the ground the poles were thoroughly treated with creosote and at present



Type of Catenary and Line Construction Used on the Canadian National Electrification at Montreal

give every indication of long life. In one particular instance due to the elimination of a curve a number of poles were removed after they had been in service for about a year and a half and were found to be perfectly sound.

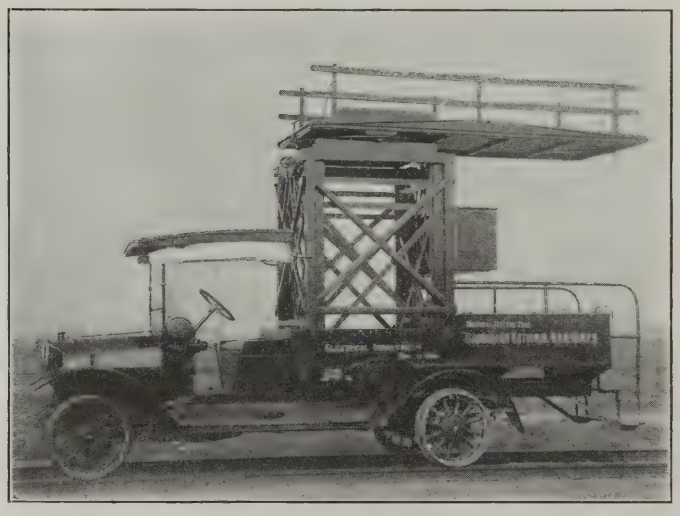
It is estimated that the messenger wires supporting the trolley will not require renewal for a number of years, possibly not for ten years; the wire is stranded galvanized cable and in general is well adapted to withstand the weather conditions.

From the sub-station at the west portal to the repair shop at Lazard, a distance of about four miles, a three-phase, 2,200-volt line is run to supply the necessary power for the repair shop. As the power requirements of the shop are comparatively small this voltage is more economical than the incoming sub-station voltage of 11,000 would be, although this section of the line is constructed for 11,000-volt operation at any time should the occasion arrive for its use. The line is composed

of No. 2 stranded copper conductors. The only deviation from the wood pole line construction occurs in the town of Cartierville where, for a distance of about 1,600 ft. through the town, steel pole construction is used for the purpose of presenting a neater appearance.

The overhead system including pole line construction, catenary suspension and trolley wires is maintained by three first-class wiremen paid on an hourly basis at the rate of 81 cents per hour. In order to facilitate line repair work the Canadian National Railways has constructed a most useful and novel tower car. The tower is built upon a Reo speed wagon equipped with flanged wheels. It consists of three sections, which, when collapsed, is 12 ft. high and when extended, 22 ft. high. Necessary tool boxes and carrying cases are included with the outfit as well as a revolving platform 4 ft. by 9 ft. Operating conditions make it desirable to be able to run this car in either direction at approximately the same speed, which necessitated some modification of the driving arrangement. In order to secure approximately the same speed backward as forward the driving shaft was cut and a new transmission was installed similar to the one already in use, but installed backward. In this way, when the gears are in reverse on the front transmission and in low on the rear transmission it is possible to secure a speed backward equal to approximately four-fifths of full speed ahead.

Although the number of failures of strictly electrical origin have been comparatively few on the electrified zone, there has been some trouble experienced with flashovers on the commutators of the sub-station generators. These have usually been occasioned by short

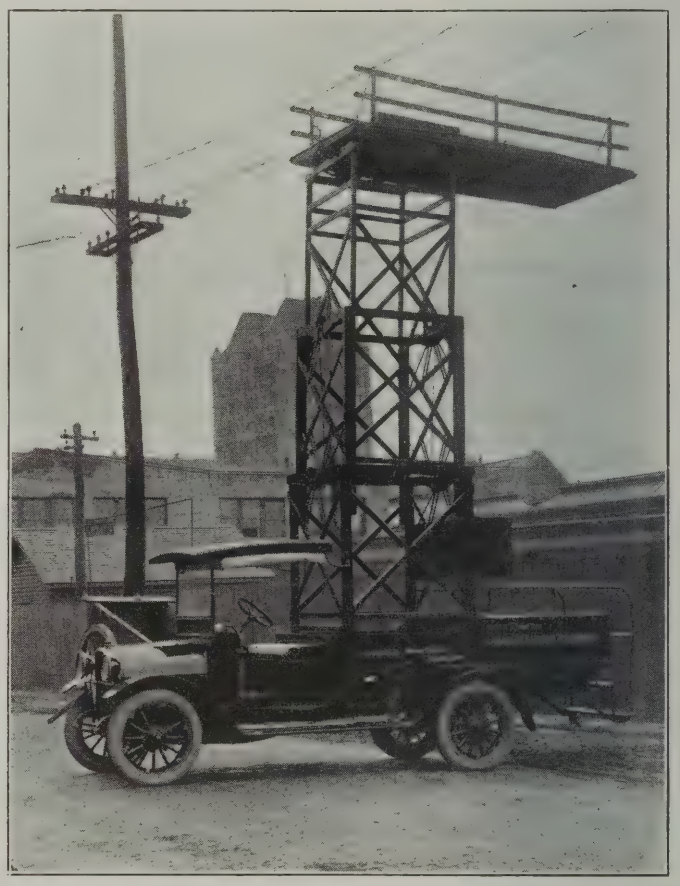


The Repair Wagon Equipped With Flanged Wheels Runs Forward or Backward at About the Same Speed

circuits on the line occurring at close proximity to the sub-station. In order to eliminate any possibility of further troubles of this kind a high speed circuit breaker built by the General Electric Company has been placed in the negative return feeder.

The arrangement of the various parts of the high speed circuit breaker is shown in the diagram on page 29. *F1* and *F2* represent a laminated field structure something like that of an ordinary alternating current magnet. The poles of *F1* and *F2* are bridged by a very light armature *A* pivoted at *P* and held in contact with the poles by a shunt coil *S1* energized from any convenient constant voltage source such as the exciter circuit or the main bus. A series bucking bar, *S2*, which electromagnetically trips the breaker is located between the poles of the field magnets and in close proximity to the armature. Thus the current flowing in the bar produces the maximum change in the armature flux, with the minimum change in the armature flux interlinking the shunt winding *S1*. The bucking bar simply shifts the flux from the armature to the air path at the right of the bucking bar thus causing the armature to release as soon as its flux is reduced to a predetermined amount.

The tension spring attached to the armature gives

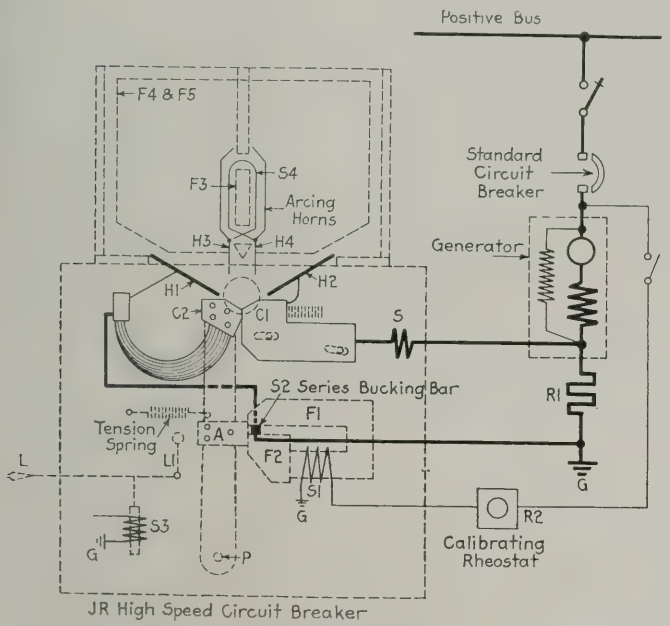


Repair Wagon With Tower Extended

the high-speed opening of the contacts and also provides a means of adjusting the breaker. On account of the relatively light armature and the fact that it is not necessary to trip any latches to release the breaker, a pull of less than 800 lb. is required of this spring for the 2,500-ampere capacity breaker. The main contacts *C1* and *C2* are of the solid copper type used so successfully on railway contactors. Contact *C1* is materially heavier than *C2* and, when the armature is released, *C1* follows *C2* for a predetermined distance, but at a much lower rate of speed, so that *C1* and *C2* begin to part simultaneously with the beginning of movement of the armature.

The blowout coil *S* is in series with the main circuit and is designed to give a very intense field of comparatively small area around the main contacts *C1* and *C2*. An additional blowout coil, *S4*, is provided in the auxiliary or arc chute and is automatically cut into the circuit during the time the arc is being ruptured. When the tips *C1* and *C2* begin to part, the series coil *S* blows the arc upward off the tips onto the arcing horns *H1*

and *H2*. As the arc moves further upward, it comes in contact with ends of the arcing horns *H3* and *H4*, between which is connected the blowout coil *S4*. This inserts the coil in the circuit and divides the arc into two parts, one of which is blown upward through the left-hand side of the chute between the arcing horns *H1* and *H3* and the other through the right-hand side of the chute between the arcing horns *H2 and H4*. The coil



Schematic Diagram of the High Speed Circuit Breaker and Connections for Installing It in the Negative Side of the Line

S4 surrounds the iron core *F3* to which is connected the field pieces *F4* and *F5* which cover practically the entire area of the auxiliary chute.

Since the installation of this high-speed circuit breaker which was made last summer, no further trouble has been experienced in flashovers at the commutators.

The High Cost of Poor Lighting*

By R. E. Simpson

When a factory owner receives a bill from the gas or electric company he feels that he has at least one definite item on which to base his overhead costs. Moreover, he doubtless notes with satisfaction that there has been little if any increase in the service rates during the last five years, and is duly thankful that in this age of high cost of everything, the prices of the gas and electricity that are necessary in his business have remained somewhere near the pre-war level. A closer analysis of the various factors entering into the overhead cost of production may disclose, however, that, owing to circumstances that are entirely within his control, he is not getting an adequate return for the money expended. A manufacturer should not be satisfied with his illumination, nor can he definitely ascertain the correct charge for that illumination until he has proved conclusively that it is impracticable to increase the productive capacity of his plant, or to decrease the percentage of spoilage, the damage to apparatus, the intentional lost time, and the accident rate, by varying the intensity levels or making other changes in his lighting system.

It is not the purpose to discuss all these factors at this time. At present our attention is to be directed to the last item—namely, to the influence of lighting upon the accident rate, and the consequent bearing of the accident rate upon the lighting bill.

It has been definitely established that ten years ago approximately 24 per cent of our industrial accidents were caused by poor lighting. In the intervening decade much progress has been made in the art of illumination and in promoting the safety of workers, with the result that this percentage has been considerably reduced. The safety-first idea was brought forth, and its influence is now evident over the entire country. This safety movement has wrought such a change in the physical safeguarding of industrial hazards that, whereas, ten years ago, accidents occurred in thousands of places where neither guards nor lights were provided, to-day most of these places are guarded so that the presence or absence of light has a relatively small bearing. The last ten years have seen marked progress in the development and use of artificial light-sources, greater attention given to the design and construction of factory buildings in order to secure a maximum amount of natural light, and the gradual introduction of factory lighting codes. The general dissemination of information on lighting questions by various interested organizations during this period has also produced beneficial results, and the larger insurance carriers have played a by no means unimportant part in this work, because a successful compensation insurance carrier must continually study the causes of accidents and devise methods for preventing them. As preventive measures are evolved the insurance carriers take steps to see that these are adopted and put in force by their policy holders, so that in the lighting field the insurance companies are continually doing missionary work.

A complete survey of accident reports for the past year, such as was made for the year 1910, has not been made; but a rather limited observation of reports, coupled with personal investigation and study, leads to the conclusion that at the present time approximately 15 per cent of our industrial accidents may be attributed to improper illumination. Even a cursory study of the subject will reveal the fact that of late years only a minor percentage of what we may term lighting accidents are due to *insufficient* illumination. We find, instead, that accidents that may be charged to faulty illumination are mostly caused (1) by continued eye-strain with its general detrimental effect on our physical well-being (and this is recognized as a distinct moral hazard), (2) by sporadic but more acute eye-strain, and (3) by glare—all brought about by *improper use of light-sources*. From this we may fairly conclude that the increase in the knowledge of the general public concerning proper illumination has by no means kept pace with the development of the art. It is highly desirable, therefore, to pay greater and more specific attention to the problem of the proper use of light-sources, as well as to the question of raising intensity standards.

There is a fairly close agreement among various investigators to the effect that there are each year more than two million non-fatal industrial accidents causing loss of time. According to the standard accident-severity

*Abstract of a paper prepared for presentation before the Fourteenth Annual Convention of the Illuminating Engineering Society, October 4 to 7, 1920, Cleveland, Ohio.

table, 95 per cent. of these accidents would be classed as temporary total-disability cases, causing an average time loss equivalent to two and one-half weeks per accident. One-tenth of one per cent, would be classed as permanent total-disability cases, with an equivalent time loss of 850 weeks per accident. The remainder would be considered permanent partial disability cases, with equivalent time loss of 190 weeks per accident. Conservative estimates of fatal accidents place the number at 25,000 annually, with an equivalent time loss in excess of 850 weeks per accident.

It might be well to say that, for the purpose of facilitating calculations of this sort, in which injuries of several types are involved, it is customary to reduce all the data to a single basis—and it is most convenient to adopt, as this basis, the loss of time that would be financially equivalent to each type of casualty. We say, for example, that a fatal accident is equivalent, on an average, to a time loss of 850 weeks—meaning thereby that the total cost, in money, would be the same, whether the man lost 850 weeks or were killed. And please note that the significance of these figures lies in the fact that they represent sums of money that *must be paid out,* in some way or other—indirectly, if not directly—and mainly by the employer.

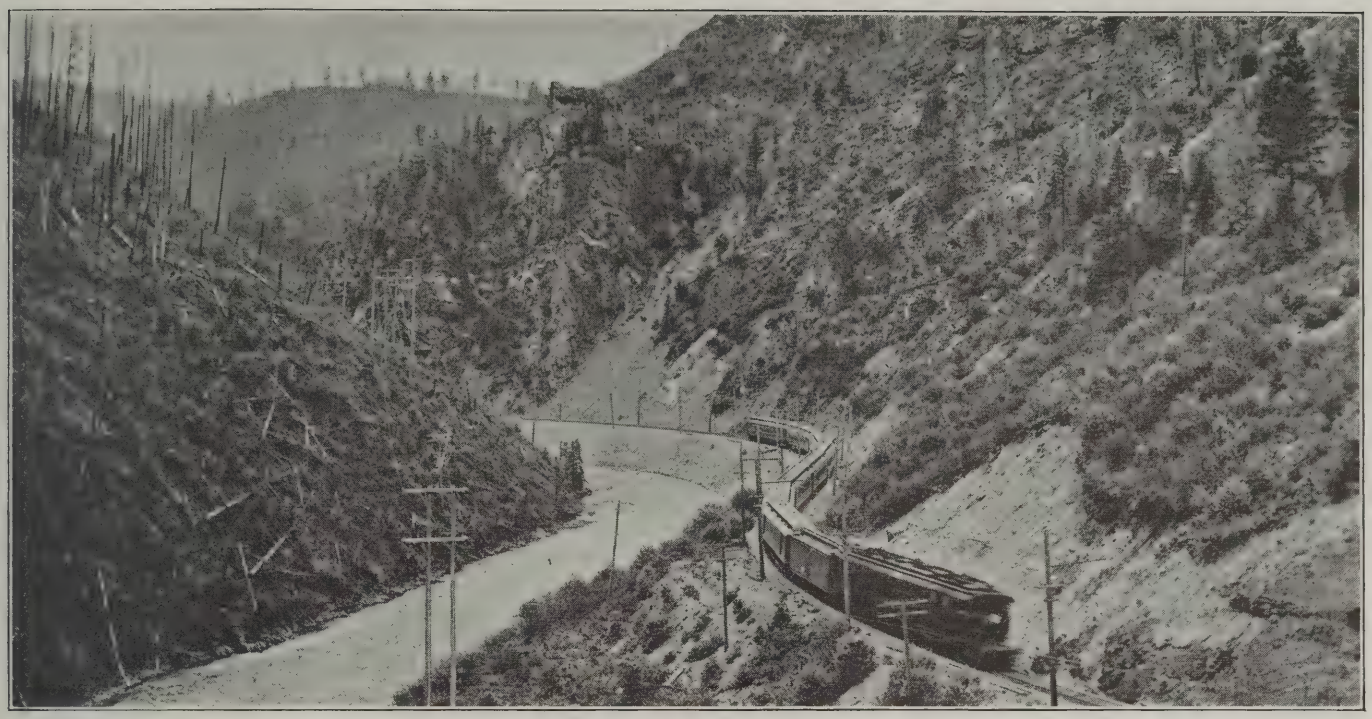
Our conception of the total economic loss that the foregoing figures involve will depend largely upon the unit-costs with which they are associated. If we conservatively estimate $20 as the average weekly wage, and assume that $20 per week are needed in addition to cover medical attendance, hospital charges, loss in production, insurance, and the various other items that enter into the cost of an accident, we find the total annual cost, in round figures, approximates $2,000,000,000—the part chargeable to poor lighting therefore being about $300,000,000. This is a sum in excess of our yearly industrial-lighting bill, and hence we see that the misuse and inadequate use of lighting facilities in industry cost more than the light itself.

Although we are accustomed to-day to think and talk in millions and billions, most of us can still grasp the essentials of a discussion based upon hundreds and thousands. It may be of interest, therefore, to consider the lighting bill as rendered by the utility company to a typical plant and see how this bill is affected by the accident-factor. To do this, we must make certain assumptions, but these can be realized in fact in any industrial center. The factory, we will say, has 1,000 employees earning an average of $40 per week each, the annual payroll therefore being $2,080,000. An average of 100 watts for lighting is allowed for each workman, but there are many faults in the installation—such as lack of reflectors, poor distribution, glare, and specular reflection. Assuming that the lamps are burned three hours per day, during a year of 300 working days, and that a rate of five cents per kilowatt hour is charged, the lighting bill will be $4,500 per year, which will be an average of $375 per month.

Compensation insurance premiums are based on the amount of the payroll, and the rate is determined by the accident experience of a given industry, modified by the experience of the particular plant under consideration. With a rate of one per cent, the premium in the case under consideration would be $20,800. The insurance carrier might pay the claims resulting from two accidents per month (on an average), and meet their own overhead costs, and still have a slight margin of profit. An experience of three accidents per month, one-third of them due to poor lighting (a not unlikely event) would leave the insurance carrier no option but to increase the rate by 50 per cent. The premium would then be $31,200—an increase of $10,400, or an average of $866 per month. We see, then, that the factory owner, in this example, is paying the utility company $375 per month for illumination, and the insurance carrier $866 per month (or nearly two and one-half times as much), because that illumination is not sufficient to permit his employees to work in safety. The cost of his illumination is therefore increased to $1,241 per month on account of this one item and the extravagance of the plan is readily apparent.

This $866 per month does not serve a progressive purpose. At best it merely assists in restoring that which our misuse of a modern convenience has damaged—that is to say, an injured worker. If part or all of this sum could be devoted to eliminating the cause of the accidents by improving the illumination, the workmen would be benefited through the safer working conditions, the owner would be reasonably certain to increase his production, decrease his spoilage, and have a steady working force, the central station would increase its revenue, and the insurance carrier would not be under the necessity of increasing its premium rate.

The Crowd Watching for King Constantine on His Departure from Lucerne



Electric Locomotives Are Used to Haul Trains Over the Most Rugged P rofiles of the St. Paul

Log of a Continuous 440-Mile Locomotive Run

Two Crews and One Locomotive Take a Through Passenger Train Over Two Electrified Divisions

By Alexander McIver*

IT seemed that I had scarcely fallen asleep in my room at the Hotel Idaho at Avery, when the sharp knock of the call boy aroused me at 1:30 a. m. I was told that No. 16 was on time. After hurrying down to the railway restaurant, I swallowed enough coffee to get me thoroughly awakened, meanwhile being entertained by the conversation of a brakeman who had just come in from a run over the Bitter Root Mountains. I then started down the track toward the round house, about one-half mile away.

The town of Avery, the western terminus of the electrified section of the Chicago, Milwaukee & St Paul, lies in the narrow canyon of the St. Joe River, at the foot of the Bitter Root Mountains. Closely hemmed in by timbered peaks and ridges, there is just room enough for the town, the railroad and the river. In the moonlight, the scene reflected the wild character of the surrounding region, which, beyond the narrow limits of the town is almost inaccessible except immediately along the railroad and the river. Forest fires have played havoc, but some of the mountains are still thickly timbered with pines and undergrowth.

If you were now to take a trip over the electrified section of the C. M. & St. P., you would be impressed by the engineering feats accomplished in building and electrifying this part of the road, by the manner in which trains are handled and by the country through which you travel.

This article is an abstract of the impressions of an electrical engineer, with a knowledge of railroading and incidentally an eye for beauty, who rode in the cab of one of the Westinghouse locomotives as it was used to haul the "Olympian" from Avery, Idaho, to Harlowton, Montana.

I arrived at the round house about forty minutes before No. 16 was due, just a little behind the engineer and the fireman. The locomotive to be taken out was No. 10301, which had come in with No. 17, The Columbian, only six hours before. A light inspection had been made by the night roundhouse force of two men assigned to this duty. The oil and water tanks for the train heating boiler had been filled. Within twenty minutes from the time we arrived the locomotive had been energized and made ready, and the engineer at the controller then proceeded to the station siding about fifteen minutes before our train was due.

Very soon the red light of the signal, followed by the glare of the headlight, told of the approach of the Olympian. As the train rounded the curve, about half a mile distant, the sharply punctuated

*Special representative, Westinghouse Electric & Manufacturing Company.

crack of the exhaust, echoing through the canyon, was ample proof that the powerful F4 Pacific type passenger engine was doing her best to bring the train in on time.. It had brought the train the one hundred and four miles from the last division point at Othello. The puffing continued to the last or until the train had come to a stop.

No. 16, the east bound Olympian, our train, had left Seattle at 9:45 the day before on its scheduled trip to Chicago, about 2,200 miles distant. It was now nearly sixteen hours on its way, having come 415 miles. The train, which is one of the best equipped in the country, consists of ten all-steel cars, including mail and baggage cars, two day coaches, two tourist sleepers, a diner, two standard sleepers and an observation club car. The weight of this train is about 725 tons.

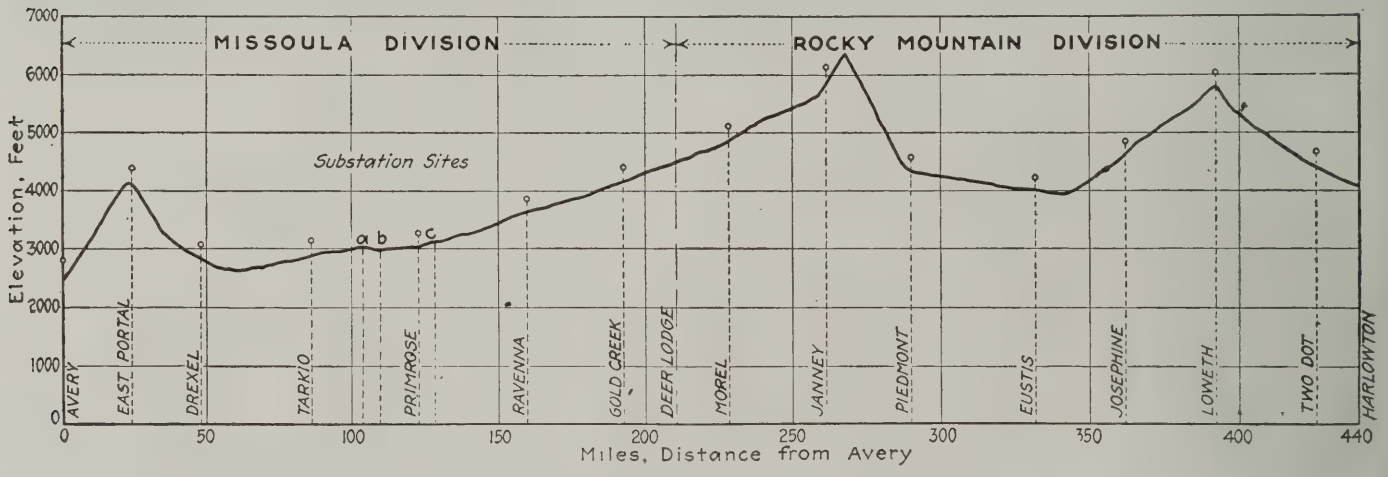
The steam engine having been uncoupled and taken away, the electric engine was backed down and coupled up by the carmen, who made the connections for the air-brake, steam line and signal and also for the train lighting. The train lighting was then transferred from the turbine-driven generator on the baggage car to the motor generator on the electric locomotive, and the resistances on the lighting panel were adjusted to give the proper voltage for train lights and for charging the car batteries.

Everything was now in readiness for the electric locomotive to start with the Olympian on its journey of four hundred and forty miles to Harlowton, across three mountain ranges, including the Continental Divide. The fireman, who had been leaning out of the cab window to watch for the conductor's signal, called "High-ball," and almost immediately the train began to move, quietly, smoothly, almost imperceptibly. Just as the train started the ammeter indicated 325 amperes, which corresponds to a tractive effort of 51,900 pounds. Within 10 seconds from the start the lever had been moved out to the seventeenth notch, the current not having exceeded 350 amperes.

After changing over to the second motor combination and moving the control lever to the fourteenth notch, Engineer Sam Winn made the running air test, then changed over to the third motor combination and again pulled the lever out to the fourteenth notch. The transitions between motor combinations were made without perceptible jar to the train. From the time the train was started until the lever was on the fourteenth notch, third combination, just two and one-half minutes had elapsed, the air test having consumed a part of the time. The current indicated by the ammeter had not exceeded 350 amperes per motor group.

Having left the St. Joe River and turned up into a canyon on the left, we were now on the 1.7 per cent grade which extends to Roland at the west portal of the Taft tunnel, a distance of twenty-one miles. Between Avery and Haugan, a distance of thirty-eight miles, there are ninety-one 10 deg. curves and seventy lesser curves, all of which are compensated to the 1.7 per cent grade; there are eighteen tunnels, and also several trestles for crossing the various narrow canyons. The trestles are heavy, all steel structures, with concrete buttresses. The roadway between Avery and Haugan is a marvel of engineering skill, of which the railway company is justly proud.

The scenery, distinctive of the Bitter Root region, is wonderful. It is a wilderness of mountains, apparently thrown together in a jumbled mass. The sharp, massive peaks, viewed by the moonlight, their sides swept by the rays of the headlight, were even more impressive than by day. From one point near the top, we could see the track over which we had passed ten miles back, now only a little more than a mile away, across the canyon, and eight hundred feet below.



Profile of the Missoula and Rocky Mountain Electrified Divisions

With the wide range of operating speeds available with this type of locomotive, the schedule running time was easily made, and with perfect control on curves; not once did the engineer resort to running on resistance points. The second and third motor combinations were both used and all three running speeds of each, the control lever being placed on the fourteenth, fifteenth or seventeenth notches, respectively, to give full field speed, first shunt speed or second shunt speed, as required in each combination.

We passed Roland, the summit of the 1.7 per cent grade, on the boundary line between Idaho and Montana, and entered the Taft tunnel. This tunnel is almost 10,000 feet in length and perfectly straight. Only the short curved snowsheds at the ends prevent a clear view through from one end to the other. It is a spacious, concrete-lined tunnel and the air is perfectly clear. During steam operation this tunnel presented a considerable problem with gas and steam from the locomotives.

We stopped at East Portal in order to make the air-brake test before starting down the 1.7 per cent grade to Haugan. The wattmeter at this point indicated that 1,980 kw.hr. had been consumed in climbing the grade.

The control lever was now pulled out to the fourth notch and then thrown off as soon as the train began to move freely down the grade. When the speed had reached 20 m.p.h., the regenerative lever having been thrown and the second motor combination having been established, the control lever was moved to the first notch and then promptly pulled out to the sixteenth. The speed gradually increased to 22 m.p.h., where it remained constant. At intervals, however, the speed was decreased at curves by moving the control lever to the fifteenth notch and increased on tangents by moving to the seventeenth. At 22 m.p.h., which speed was maintained for some distance, the field current was 280 amperes and the line current 290 amperes. At a speed of 30 m.p.h. the line current was 390 amperes and the field current 167 amperes. During regeneration the voltmeter indicated 3,200 volts on the line.

Shortly after leaving East Portal we could see, in the canyon below, the lights of Taft, a station on the Northern Pacific. It is not much of a town now, but during the days of railway and tunnel construction it was a lively place, with its thirty-eight saloons and twenty-seven eating houses. We arrived at Saltese, eight miles from East Portal, on time; we stopped and took siding here for No. 15, the west bound Olympian, locomotive No. 10304,

Along the St. Paul Right of Way on the Eastern Slope of the Bitter Roots

also on time. Here we intersected the old Mullan Trail, now called the Yellowstone Trail, which we were to follow pretty closely for a distance of 292 miles. After leaving Saltese, three minutes late on account of the meet with No. 15, regeneration in the second motor combination was again used for about four miles. For the remaining 1½ miles to Haugan the train was allowed to coast, attaining a speed of 50 m.p.h., thereby arriving at Haugan on time.

Haugan, at the bottom of the 1.7 per cent grade, is the helper station for freight trains between this point and Avery. The watt meter here indicated that 350 kw.hr. had been returned to the line by regeneration since leaving East Portal. Between Haugan and St. Regis, a distance of 19.2 miles, there is a drop of 470 feet; the maximum descending grade being 1 per cent. After accelerating to a speed of 35 m.p.h., regeneration in the third combination was used, the manipulation of the control being the same as described above. A speed of 45 to 50 m.p.h. was maintained for some distance, being reduced slightly for curves by the regenerative control.

From Haugan the scenery changes; we enter a beautiful canyon which we follow to St. Regis. Here we cross the St. Regis River, called Clark Fork further down, one of the forks of the Columbia. At Thompson's Falls, a few miles below, there is the 40,000 hp. hydro-electric development of the Montana Power Company, which is connected up with the general system supplying power for operating the electric locomotives. St. Regis is the lowest point on the electrified system excepting Avery. The elevation above sea level here is 2,680 feet. We had dropped down 1,483 feet since leaving East Portal. From St. Regis the road follows the river for about 190 miles to the headwaters near Butte and Anaconda. The name of the river changes several times, being later called the Missoula, Hell Gate, the Deer Lodge and then Silver Bow. For several miles above St. Regis the river winds through a deep gorge.

The distance between St. Regis and Butte is 195 miles. The rise in elevation is 2,858 feet. The grade ranges from .2 per cent to .4 per cent to within a few miles of Butte, where it becomes .6 per cent. The curves are all easy, a speed of 50 m.p.h. being allowable except for a short stretch in Silver Bow Canyon near Butte.

We stopped at Superior on flag signal. Our next stop was Alberton, 100.5 miles from Avery. This was the old division point in steam days. The roundhouse is now completely torn down, nothing much being left to mark the spot except the abandoned coal dock and the old turntable pit now used for a swimming hole. There is a railway restaurant in the station, and a five-minute stop is made for luncheon.

Day was beginning to break as we entered the wide, fertile section of the Missoula Valley. This valley was settled a great many years ago by French-Canadians, who have since grown rich on their big ranches. Frenchtown is an interesting and attractive looking place. To the right, just before we get to Missoula, we could see the wide valley of the Bitter Root stretching toward the south, with high snow-covered mountains for many miles on either side. This valley is one of the richest fruit growing and agricultural sections of the state. It was down this valley to this point that the Lewis and Clark expedition came 115 years ago, after crossing the divide from the Big Hole basin. From here they turned southwest to cross the Bitter Root Mountains, on their way to the Columbia River and the Pacific Coast.

At the junction of the Bitter Root and Missoula valleys lies Missoula, the metropolis of the section, a beautiful and prosperous city with a population of 15,000.

Between Missoula and Deer Lodge, a distance of 80 miles, there are no scheduled stops. The climb to Deer Lodge is 1,330 feet. The running time is two hours and six minutes. The roadway follows the river up the narrow Hell Gate Canyon. At Gold Creek we were reminded by a monument that in the creek which bears the name gold was first discovered in Montana about sixty years ago. A little further on we passed the point, marked by a sign, where the last spike was driven in 1909, completing the road between the East and West. After passing through Garrison tunnel we entered the Deer Lodge Valley, which expands to a width of ten miles or more for a distance of thirty-five miles.

A few miles further on we came to Deer Lodge, the end of the Missoula Division, where crews are changed. When necessary for inspection, the locomotive is also changed, as the shops of the electrified district are located at this point. Regular inspections are made on a 5,000-mile basis. Our locomotive was not due for inspection,

and Engineer Winn had reported from Alberton that it was "O. K." to go through. All that was necessary was to replenish the water storage tanks for the train heating boiler. The oil storage capacity of 750 gallons is more than ample for the through trip, but the water capacity of 3,500 gallons is not sufficient in cold weather. The water tanks are readily filled during the ten minutes' stop by means of hose and pipe lines at points where locomotives make the station stops.

Wattmeter readings at this point indicated that 6,690 kw.hr. had been consumed between Avery and Deer Lodge, and that 360 kw.hr. had been returned to the line by regeneration.

The Olympian, with Engineer Barnes now at the controller left Deer Lodge on time at 9.25 a. m. The running air test, which is required on all trains leaving Deer Lodge, was made after the train was up to a fair speed in the 3rd combination.

About one-half mile out we passed the railroad shops and freight yards on the right. On the left just across the river are the walls and buildings of the Montana State Prison. Then on the right we get the full view of Mt. Powell rising majestically nearly 6,000 feet above Deer Lodge Valley; in the distance at the other end of the valley, thirty miles away, the lofty, precipitous Cable Range.

But Deer Lodge is a place much too interesting to leave behind without some further mention. One of the oldest towns in the state, it played an important and dramatic part in the early history and development of this section. It was the scene, or center, of thrilling adventures in early days, about which old timers, who are still hale and hearty, tell stirring tales. Located in the heart of a rich and extensive ranching section, Deer Lodge is a thriving and up-to-date little city of four thousand, with fine new public buildings and beautiful homes.

Our next scheduled stop was Butte, 40.5 miles south of Deer Lodge. Butte is 1,018 feet higher in elevation than Deer Lodge; the scheduled running time from Deer Lodge is one hour and twenty minutes. A few miles out the big stack of the Anaconda Copper Reduction Works comes into view. This stack towers 585 feet above its foundation on top of the slope where the reduction works are located. A little further on we could see, not far from the railroad, a series of long dams, and big settling pools for saving the copper held in suspension, which otherwise would be carried down the Deer Lodge River.

We suddenly left the valley and wound through the picturesque Silver Bow Canyon, four or five miles in length. Through the same narrow canyon there are the tracks of the Northern Pacific and the Butte, Anaconda & Pacific Railways, the latter road also being electrified. Coming out on to the flats we had a straight run for several miles. This brought us to the arena of some of the biggest mining activities in the world, where back in the '60's, gold was first mined, then silver and then copper. Since 1882, when railway connections were first established, copper mining has been the principal industry. From this district more than eight billion pounds of copper have been taken. At present, more than one million pounds net, per day, can be produced. Considerable gold and silver are obtained with the copper. The zinc mines of the district are also becoming important. Butte, with a population of 50,000 or more, is supported entirely by the mines; while Anaconda, with its 15,000, depends entirely on the reduction works.

The Missoula Gorge On the St. Paul Near Missoula, Montana

We went beyond the "Y" at Butte and backed into the station, a handsome building recently erected. The schedule stop here is ten minutes.

Leaving Butte on schedule at 10.55 a. m., we headed out over the "Y," stopped to close the switch and then passed through the Butte Yards, across Montana street, where there is a grade crossing with the city street car line, both lines having long overhead dead sections. The locomotive spanned this section by raising both pantagraphs. At Newcomb, seven miles from Butte, we stopped five minutes for an air-brake test and inspection. We then started up the 1.65 per cent grade of the Continental Divide, the summit of which is ten miles away. On starting here, the controller was brought up to the 17th notch, 3rd combination, within 1½ minutes with a

maximum accelerating current of 375 amperes. This was as difficult a place to start as any on our trip and it is noteworthy that the starting and accelerating current was only 66 per cent of the maximum current which can be used before wheel slipping will occur, when sand is applied.

At Janney we took siding to meet train No. 17, the West-bound Columbian. Near the top I looked back for a view of Butte, but there was too much smoke. At night, from this and other points on the grade, the lights of Butte can be seen, thousands of them, brilliant and twinkling, in a compact group, on the opposite slope of the valley, seven or eight miles away and several hundred feet lower.

At Penfield we were delayed seven minutes, having to stop while a freight train of 100 cars, handled by two electric locomotives, "sawed by," through the passing track. We then entered the Pipestone Pass Tunnel, just above which the Yellowstone Trail crosses the divide. At the east end of the tunnel a sign marks the Continental Divide, at an elevation of 6,322 feet. At Donald, one-half mile farther on, we stopped five minutes to make the air brake test. Wattmeter readings here indicated a total of 2,610 kw.hr. consumed since leaving Deer Lodge.

The brakes having been released, just enough power was applied to get the train promptly under way. The regenerative lever having been thrown and the 2nd motor combination established, the speed was allowed to increase to 20 m.p.h. when the control lever was moved to the 1st notch and then promptly out to the 16th. Two movements of the lever to the 15th notch and back to the 16th gave the desired speed, which was maintained all the way down the 20 miles of the 2 per cent grade without further manipulation, except at the two slight "dips" near the bottom where the field was slightly weakened to maintain the speed.

The scenery here is very impressive, as one might expect to find in crossing the Continental Divide, but for about seven miles our view was confined to the nearby landscape. Just east of Grace station we get a view of the country beyond and the Ruby Valley, a thousand feet below. As the view expands we get it full in all its beauty and grandeur. The valley here is five miles wide and the mountains on the other side, high and steep, with snow-capped peaks rise abruptly from the level. The valley extends for many miles up the Jefferson River and its tributaries through a region made famous by gulches fabulously rich in gold, by road-agents and by the Vigilantes. The Vigilante Trail of early days, now a Park to Park highway, passes through this valley. Here the Lewis and Clark Expedition passed southwest to the Big Hole basin where they crossed the divide to go down the Bitter Root Valley.

Beyond Cedric we passed around the horsehoe curve. From Vendome the road is perfectly straight to Piedmont 5.5 miles away. The ruling grade is 2 per cent with two intermediate flat stretches.

As we passed the substation about one mile beyond Piedmont, the watt meter indicated that 1,110 kw.hr. had been returned to the line by regeneration between Donald and this point.

From Piedmont to Lombard, a distance of 53 miles, the descending grade is .3 per cent maximum. Shortly after leaving Piedmont we crossed the Jefferson River, which we followed to Three Forks. For about eight miles between Jefferson Island and Alcazar we passed through the beautiful Jefferson Canyon. This river and canyon were explored by Lewis and Clark and were described by them in much detail. In the canyon section not far from the river, there is a huge cavern only slightly explored as yet, but probably rivaling the Mammoth Cave. It has been named the Lewis and Clark Cavern and dedicated by Congress as a national monument.

The Olympian Leaving the Station at Butte, Montana

Three Forks, the next stop, was an old division point where steam locomotives were changed. There is a railway restaurant here and a five-minute stop is made for luncheon.

Soon after leaving Three Forks, Engineer Barnes called our attention to the source of the Missouri River from which the town gets its name. Here we could see the junction of the three rivers, the Jefferson, the Madison and the Gallatin, the Gallatin coming in a little below the

junction of the other two. These rivers were named by Lewis and Clark, who made camp on the elevated ground at the junction. It was here they made their headquarters during trips of exploration around this region. The elevation above sea level at this point is 4030 feet. By the route of the river it is several thousand miles to the outlet in the Gulf of Mexico.

From its source we follow the river, which flows through gorge after gorge, further down furnishing the power for the operation of the Milwaukee trains, for mining operations and for lighting and various industrial purposes throughout the western half of Montana. The capacity of the various Hydro-Electric Developments in this state aggregates 219,000 hp., with a possible development of nearly 3,000,000 hp.

We crossed the Missouri at Lombard, sixteen miles from its source and just below the outlet of Sixteen Mile Creek. We stopped at Lombard station, where there is some exchange of traffic with the Northern Pacific which follows the river, passing under the Milwaukee bridge.

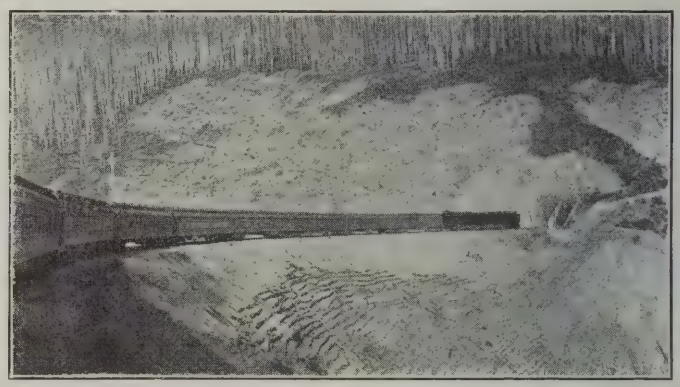
From Lombard to Loweth, the summit of the Belt Range Mountains, 49.5 miles distant, there is a steady climb, the difference in elevation being 1800 feet. Between Lombard and Ringling, 36.2 miles distant, the maximum grade is 1 per cent, the average grade .7 per cent. Between Ringling and Loweth the grade is 1 per cent.

The track at Lombard station is curved and the starting of a heavy train is not easy. After a four-minute stop, we were under way and up to the 17th notch, 3rd combination, in less than two minutes with a maximum accelerating current of 375 amperes. From here to Harlowton the roadway follows the general course of the old Montana or "Jawbone" railroad. As soon as we left Lombard we entered the first section of the narrow canyon of Sixteen Mile Creek and winding through its narrow gorge for four or five miles we emerged into a wide valley and then, eight or ten miles further on, we entered the second gorge.

The wonderful scenery in this canyon changes so completely with every turn, there is such great variety in the shapes and formations of the cliffs and rocks which form its walls, that from a moving train it is impossible to take in all of its exquisite beauty. First on one side and then on the other we see the creek celebrated for its trout and, along its tortuous course, the abandoned roadbed of the old "Jawbone." On the Milwaukee road in this canyon section there are eight tunnels.

At Maudlow and at Sixteen we made stops which were not on our schedule, thereby losing four minutes; proceeding to Ringling we made a four-minute stop there. The watt meter there indicated that 4,890 kw.hr. had been consumed since leaving Deer Lodge.

From Ringling to Loweth, a distance of 13.3 miles, the grade is 1 per cent. On starting, the control lever was brought to the 17th notch, 3rd combination, within sixty-five seconds from the start, the maximum accelerating current being 375 amperes. On the way up the grade the average speed was 35 m.p.h., current per motor circuit 245 amperes, the line voltage being 2800.



A St. Paul Passenger Train as Seen from the Observation Car

At Loweth we crossed the Belt Range Mountains at an altitude of 5788 feet. Here we made a five minute stop for inspection and test of the air brakes before starting down the steep grade to Bruno. The wattmeter here indicated that 590 kw.hr. had been consumed between Ringling and Loweth.

From Loweth to Bruno, 4.2 miles, the descending grade is 2 per cent; from Bruno to Lennep, 5.6 miles, 1.35 per cent; from Lennep to Two Dot, 23.5 miles, 1 per cent, and from Two Dot to Harlowton, 12 miles, it ranges from .8 per cent to .6 per cent.

After the air brake test, power was used long enough to start the train and when the speed had increased to 23 m.p.h. the motors being in the 2nd combination, the regenerative lever was thrown and the control lever brought up to the 16th notch. Then, with one movement of the lever to the 17th notch, the speed was brought to 27 m.p.h., remaining constant down the steepest part of the grade to Bruno, where the field was weakened another notch, allowing the same speed to be maintained on the lesser grade to Lennep. Beyond Lennep, the controller

SUMMARY OF DATA TAKEN ON TRAIN NO. 16, DECEMBER, 1920

Location	Miles	Elev.	Time	Ruling Grade	Watt Hour Meter Readings		
					Train Lighting K.W.H.	Motoring K.W.H.	Regeneration K.W.H.
Avery	....	2,495	2:40 a.m.	.....	7,429	606,200	279,700
East Portal	23.7	4,163	3:51	+1.7%	7,433	608,180	279,700
Haugan	37.8	3,150	4:34	—1.7%	7,435	608,290	280,060
St. Regis	57.1	2,680	5:15	— .8%	7,438	608,430	280,060
Alberton	100.5	3,040	6:20	+ .4%	7,441	609,730	280,060
Deer Lodge	211.2	4,520	9:25	+ .4%	7,452	612,890	280,060
Butte	251.8	5,538	10:55	+1.08%	7,455	614,430	280,060
Newcomb	258.8	5,617	11:16	+ .9%	.....	614,690	280,060
Donald	269.1	6,322	11:47	+1.66%	.....	615,500	280,070
Piedmont	289.8	4,357	12:35 p.m.	—2%	.....	615,500	281,170
Three Forks	324.3	4,066	1:35	— .3%	.....	615.750	281,170
Lombard	343.7	3,987	2:05	— .3%	.....	616,030	281,170
Loweth	393.2	5,788	3:58	+1%	.....	618,370	281,170
Harlowton	438.6	4,163	5:25	—2%	7,481	618,430	281,470
Total	438.6	.....	14 hrs. 45 min.	.....	52 K.W.H.	12,230 K.W.H.	1,770 K.W.H.

was thrown off and after the speed had increased to 30 m.p.h. regeneration in the No. 3 combination was used, the control lever being moved up to the 16th notch and the motor fields adjusted by two or three movements of the lever to bring the speed to 55 m.p.h. Later the speed was increased to 60 m.p.h. by two short movements of the lever. At the 55-mile speed, I noticed that the line current was 100 amperes and the field current 120 amperes, the line voltage being 3200.

We then rode down the beautiful rolling Musselshell Valley famed for its big ranches of early days. A stop was made at Martinsdale. From there, after accelerating to a speed of 50 m.p.h., regeneration in the 3rd combination was again used. Four miles below Martinsdale, at Groveland, we met No. 15, the west-bound Olympian, already in the siding. On nearing Two Dot, the speed was brought down to 40 m.p.h. by means of the regenerative control at which speed the air-brakes were applied, the controller thrown off, and the train brought to a stop. This place is named after one of the big ranches nearby. The last of the fourteen substations is located at this point.

We arrived at Harlowton on time at 5.25 P. M. The Olympian was here turned over to the steam engine whose run was to be 104.5 miles to the next division point east at Miles City. The electric locomotive was taken to the roundhouse to be inspected before starting on the return trip with No. 17 at 5.05 A. M. the following day. According to the report of Engineer Barnes, there had been a total of 49 minutes delay, the three five-minute stops for brake test being included, the balance of the time having been consumed by slow orders, train meets and non-scheduled station stops. Deducting the 49 minutes delay from the schedule time of eight hours between Deer Lodge and Harlowton, the actual running time was 7 hours and 11 minutes. There are 22 stops between Avery and Harlowton, including 4 stops for testing air brakes and two stops at the Butte Wye. The wattmeter indicated that 300 kw. hr. had been returned to the line by regeneration from Loweth to Harlowton. The total kw. hr. consumed between Deer Lodge and Harlowton was 5,540. The total kw. hr. regenerated between Deer Lodge and Harlowton was 1,410 (net 4,130).

The trip had been a long one and although I had been standing for a good part of the way, I was not very tired.

Our locomotive, No. 10301, went through on No. 17 to Avery next day and returned to Harlowton with No. 16 the day after, and the following day went back to Avery with No. 17. It has made seven through trips in seven successive days and will probably make three or four more trips before it is taken off for inspection at Deer Lodge. It is common practice for these locomotives to make ten and twelve through trips of 440 miles each in as many consecutive days. For several days' running, these electric locomotives have passed through Deer Lodge on their runs between Harlowton and Avery without any of them having to be taken off for any reason.

The following is a summary of the power consumed and regenerated on our trip with No. 10301:

From Avery to Deer Lodge	6,690	K.W.H. consumed
	360	K.W.H. regenerated
	6,330	K.W.H. net
Deer Lodge to Harlowton	5,540	K.W.H. consumed
	1,410	K.W.H. regenerated
	4,130	K.W.H. net
Avery to Harlowton	12,230	K.W.H. consumed
	1,770	K.W.H. regenerated
	10,460	K.W.H. net

LOCOMOTIVE OPERATION ON C. M. ST. P. RY., BETWEEN HARLOWTON AND AVERY

	Train No. 16, Avery-Harlowton	Train No. 17, Harlowton-Avery	Train No. 18, Avery-Harlowton	Train No. 15, Harlowton-Avery
July 18	10303—10308	10302	10304	10307—10303
July 19	10303	10308	10302	10304
July 20	10308	10303	10304	10302
July 21	10303	10308	10302—10307	10304—10301
July 22	10308	10303—10304	10301	10307
July 23	10304	10308	10307	10301
July 24	10308	10304	10301	10307
July 25	10304	10308	10307	10301
July 26	10308	10304	10301	10307
July 27	10304—10303	10308	10308	10301
July 28	10307	10303	10301	10308
July 29	10303	10307	10308—10302	10301
July 30	10307	10303—10305	10301	10302—10308
July 31	10305—10303	10307	10308	10301

SUMMARY OF PERFORMANCE

Locomotive No.	Number Through Trips	Number Half Trips	Total Mileage
10301	10	1	4,620
10302	3	3	1,980
10303	5	6	3,520
10304	7	3	3,740
10305	..	2	440
10307	9	2	4,400
10308	12	3	5,940

SUMMARY OF LOCOMOTIVE PERFORMANCE FROM MAY 1st TO NOVEMBER 30th, 1920

Loco. No	Number Through Trips	Number Half Trips	Mileage	Total Mileage to Date
10301	66	39	37,549	52,232
10302	73	56	43,552	63,033
10303	55	56	36,946	52,617
10304	58	52	37,654	52,357
10305*	64	36	32,540	44,979
10306	90	40	48,295	63,013
10307	86	37	46,786	46,786
10308	84	43	46,836	58,595
10309	66	50	40,334	40,334

*No. 10305 was out of service during May, June and July, 1920.

Secretary Payne on the Super Power Plan

The annual report of the Secretary of the Interior contains the following regarding the superpower survey:

"Congress at its last session placed upon this department the duty of making a special investigation of the possible economy in fuel, labor, and material that could be secured by electrification of the railroads and industries of the region between Boston and Washington. The plan contemplated is a unified system of power generation and power distribution, and its investigation has been called the superpower survey. This is now under way. The engineering profession and large business interests are giving this project support that is at once an indorsement and a promise of public confidence. The engineering staff engaged in this intensive study of the power needs and the means of meeting that demand includes men who have done pioneer work in applying electricity to the use of man; while serving on an advisory board are men of vision and experience, representing our larger railroads as well as electric railways, our manufacturing and mining industries, and the engineering and chemical professions, busy men who have accepted my invitation to help direct this investigation along lines of greatest practical usefulness. Every industry that has to do with either making power or using power is giving generous co-operation.

"The area being studied, while only a small fraction of the United States—2 per cent—uses 24 per cent of the electric output of the central stations of the country

and produces about 47 per cent of its manufactured products. It is properly termed the finishing shop of American industry. The report of this investigation will be completed June 30 next, and its purpose is to give an engineering solution to the problem of the demand of the nation for greater production and better transportation. That answer is electrification, but its details must include the accurate statement of costs in capital and of savings in coal and labor. I believe the report will deserve public confidence."

Gear and Shaft Drive with No Bearing on the Car Axle

A NEW type of gear and shaft drive for car lighting generators has been proposed by A. H. Matthews, Canadian National, Quebec, Canada. The device is unique in that it does not include a bearing on the car axle or a quill around the axle and the main driving gear

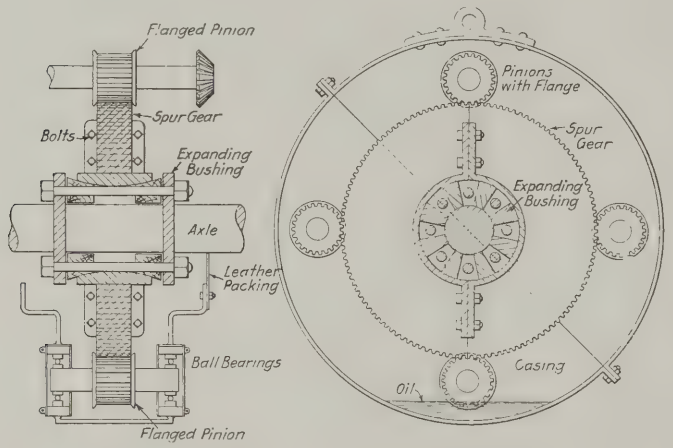


Fig. 1—Drawing Showing How the Split Gear is Attached to Its Axle and How the Pinions Are Placed in the Case

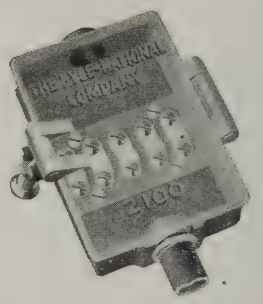
is applied to a straight axle. The main driving gear is made in two halves bolted together and applied to the axle by an expanding bushing as shown in Fig. 1. Over this gear is placed a casing, also made in two parts, containing four flanged pinions which mesh with the main spur gear as shown. The pinion bearings are fitted rigidly into the case. The case is partly filled with oil or grease and leather packing around the axle attached to the case is used to retain the lubricant and to keep dirt out of the gears.

The flanged pinion at the top drives a pair of bevel gears which in turn transmit the power through a shaft to the generator. Two universal joints and a sliding coupling give the shaft the required flexibility. A hanger prevents the shaft from dropping on the roadbed in case it should let go at either end. The gear case is kept from turning by a link which is attached to the end sill of the truck and there is a spring interposed in this link to compensate for shocks such as are caused by the coupling of cars.

Mr. Matthews has proposed another similar device which differs from this in that the expanding bushing is eliminated and the main spur gear is applied to a specially turned axle.

A New Junction Box

A new junction box, manufactured by the Pyle-National Company, Chicago, is shown in the illustration. It is made from cast iron and may be used for connecting circuits at the cab and smoke box end of conduit. A water-proof cover is provided which is secured to the box by a convenient latch. The conduit connection at one end can be removed without disturbing the wires in the conduit, and two branch line connections may be added by drilling through the sides of the box. In addition a ¾-in. knockout is provided at the back. For other connections, each end is tapped for ¾-in. fittings. The inside dimensions are 6⅝ in. long, 4½ in. wide, and 1½ in. deep. An ebony board connecting block, 3⅞ in. long, 2½ in. wide and ¼ in. thick is provided. This is fitted with 10 screw terminals connected by buss bars.



Junction Box for Locomotive Wiring

The usefulness of a junction box is readily apparent for it not only furnishes a convenient point for testing but also permits the various circuits to be disconnected when the locomotive is shopped for repairs.

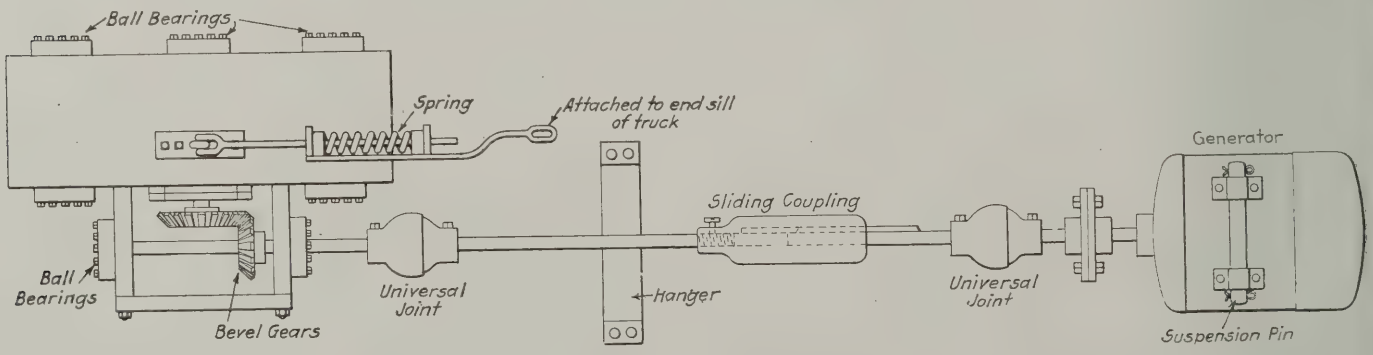


Fig. 2—Plan View of the Complete Device Showing General Arrangement of Parts

Regenerative Braking With Electric Locomotives

A Simplified Explanation of the Manner in Which Trains Are Retarded When Descending Grades

By A. J. Manson

MUCH has been said and written about the advantages of the electric locomotives for railroad operation. While the steam locomotive has improved rapidly in design by the use of economizers and superheaters, the electric locomotive has more than kept pace with it. Its performance in connection with terminals and tunnels is generally appreciated and its advantages well known. The electric locomotive has taken its place in switching service resulting in marked economy, and finally, but not by any means the least important, it has entered the field of freight haulage—the hauling of freight over the heavy grades of mountain divisions. In this last mentioned service there is one great advantage enjoyed by the electric locomotive which stands out prominently, an advantage about which little has been written, and an advantage which cannot be even attempted or realized by the steam locomotive, namely, regeneration. Regeneration is the taking of the energy available on account of the train descending a grade and which normally with steam operation is dissipated as heat at the brake shoes, and using this energy to return to the electrical conductor, electrical energy, which helps to supply power to some other train operating against grade, thus requiring less power to be taken from the main power station than would be the case without regeneration.

Considerable energy is available (expressed in foot pounds or horsepower) when a large heavy freight train or passenger train is running down grade. Suppose for instance, that there was a 3,000-ton train running down a 2 per cent grade at 14 miles per hour. The horsepower available can be calculated as follows: For each 1 per cent grade, the down pull along the grade is 20 lb. per ton (law of physics) so that on the 2 per cent grade there will be 40 lb. per ton, minus the friction of the train, which in this case we will assume as 6 lb. per ton. There is then a net amount of 34 lb. per ton, which with a 3,000-ton train made up of 3,000-ton trailing load and a 250-ton locomotive gives 108,250 lb. The speed in feet per minute at 14 miles per hour is 1,232, so that the horsepower to be dissipated at the brakeshoes as heat, or else as available for regeneration, is

$$108{,}250 \times 1{,}232 \div 33{,}000 = 4{,}041 \text{ hp.}$$

Returning electric power to the conductor or line means that electric power is actually generated on the locomotive and the horsepower developed on the down grade is converted into watts. The logical procedure is to make use of the electric motors, which normally supply the motive power for the propulsion of the train, for generating the electric current to be put into the line and this is exactly what is done. The motor is connected to the axles on the electric locomotive by gearing, side rods, or a combination of both, so that these motors revolve at all times with the revolution of the drivers. Power is required to generate electricity and the relation is such that 746 watts equal 1 horsepower if the efficiency of the machine is disregarded. We have seen that regeneration is the converting of the energy of the train descending the grade represented by horsepower, into electrical power or watts. If a method is provided for controlling the amount of electrical power returned, this electrical power can be kept constant or can be varied to suit the grade which the train is descending and to absorb the amount of stored energy. With this regulation it is possible (within limits) to absorb this potential energy of the train and to regenerate sufficient power so that the speed of the train down the grade is under perfect control without the use of air brakes, they being held in reserve for emergency and the stopping of the train.

While, in general, regeneration is the same for all systems, in that it provides a means for retardation of the train and for returning of power to the overhead line, still there is some difference. In order to understand what is happening it may be well to consider the fundamental principles of the electric motor. The subject should be considered under two different headings, namely, first, regeneration with direct current and single phase series variable speed motors, and second, with the three phase or constant speed motors.

Direct Current and Single Phase Regeneration

In the case of the direct current application we will assume that the motors are of the series commutating type, this type of motor having the proper characteristics for general railway work. The series motor gets its name from the arrangement of connection between the armature and the field, these two parts of the motor being connected in series, so that the same current which flows through the armature also flows through the field coil. Since the same current passes through both the field and the armature the strength of the field varies with the armature or load current, which affects both the speed and the torque of the motor. This torque is represented by the product of the field strength multiplied by the current flowing through the armature, so that the pull or torque increases rapidly with the increasing current which results when the speed is decreased.

In order to regenerate with the direct current system the voltage generated by the motors must be greater than the voltage or pressure on the electrical conductor, and this pressure generated must be under control. It is analogous to the pressure in a water pipe. The condi-

tions to be met are similar. In order to force water into a pipe which may be at 100 lb. pressure, a greater pressure must be used to overcome this pressure in the pipe. The motors must therefore become, for the time being, electric generators. While it is true that a series motor can be made to generate current and act in the capacity of a generator, if the fields of the motors are reversed, it is very unstable. It is necessary to make certain changes in the motor connections so as to satisfactorily control the voltage generated. There are certain vital conditions which must be met and overcome. It is necessary to provide controlling apparatus so as to take care of variable conditions which are met in the direct current system. For instance, the line voltage may suddenly be reduced at the locomotive which is regenerating, due to heavy trains starting up in the immediate neighborhood. Under these conditions, with a certain voltage being generated by the motors, the regenerated current would immediately increase. With the motors connected as series motors, this immediately would increase the field strength, which in turn would increase the regenerated current so that an excessive overload would be thrown on the entire equipment. On the other hand, if the line voltage should rise after a certain stable voltage existed on the motors, then the difference in voltage would be less, resulting in a decrease of regenerated current. The field excitation would therefore be decreased and a further decrease in current would result and possibly might be reduced to zero. If the condition persisted still further excessive current in the opposite direction would build up and serious difficulties would result. In fact, these changes could happen so quickly and frequently that the time element of relays and controlling apparatus could hardly be made sensitive enough to properly safeguard and be effective.

It therefore comes down to the question of separating the fields from the armature, changing the series motors into shunt generators, and exciting the fields of the motor from some separate source. We know that the main fields of the d. c. motors consist of a very few turns of wire or copper of low resistance, so that it would be impossible to excite these fields from the main voltage supply, as the excitation would be too great for the voltage desired.

Instead of the series generator, therefore, we have a shunt generator, and by adjusting and controlling the amount of current flowing through the separately excited field which determines the strength of the field and the number of lines of force, sufficient voltage can be generated in the armature to force current back into the line against the line voltage. These fields could be separately excited from some source such as a storage battery, but a much better arrangement and a more practical one is to furnish this power from a motor generator set.

There are many methods possible in connection with this separate excitation. Any scheme to be effective must be automatic within limits so as to secure motor stability and weaken the field as the regenerated current increases, due to a momentary drop in the line voltage. Also it must be effective under reverse conditions wherein the line voltage increases.

With this separation of the field from the armature the motor (now used as a generator) is no longer the self-contained and automatic unit which it is when operating as a motor. When operating as a motor the field strength and the armature current are always equal or in proportion to each other, and the motor automatically, by design, is stable. When operating as the generator the conditions are entirely different. The field strength is no longer the same as the armature strength and when the motor is running at high speed, a very low field excitation is all that is necessary to give the desired voltage for regeneration, and a certain distortion of armature flux exists. The torque which this motor, operating as a generator, exerts to absorb the mechanical energy of the train, is, however, proportional to the product of the armature current and the field strength. Naturally it follows that at the high speed with the low field strength

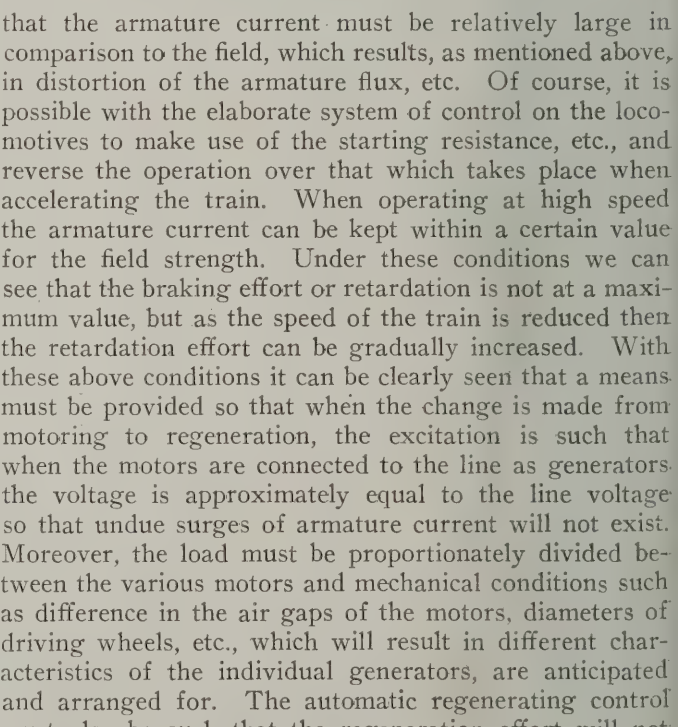


Fig. 1—Diagrammatic Connections Showing Scheme for Regeneration Using Stabilizing Resistance and Axle Driven Generator—Direct Current System.

that the armature current must be relatively large in comparison to the field, which results, as mentioned above, in distortion of the armature flux, etc. Of course, it is possible with the elaborate system of control on the locomotives to make use of the starting resistance, etc., and reverse the operation over that which takes place when accelerating the train. When operating at high speed the armature current can be kept within a certain value for the field strength. Under these conditions we can see that the braking effort or retardation is not at a maximum value, but as the speed of the train is reduced then the retardation effort can be gradually increased. With these above conditions it can be clearly seen that a means must be provided so that when the change is made from motoring to regeneration, the excitation is such that when the motors are connected to the line as generators the voltage is approximately equal to the line voltage so that undue surges of armature current will not exist. Moreover, the load must be proportionately divided between the various motors and mechanical conditions such as difference in the air gaps of the motors, diameters of driving wheels, etc., which will result in different characteristics of the individual generators, are anticipated and arranged for. The automatic regenerating control must also be such that the regeneration effort will not be too quickly applied.

These conditions have been met by the electrical engineers and very successful regeneration braking has been accomplished with direct current electric locomotives, with a minimum amount of excess apparatus and with additional complications which are practically negligible.

Such a scheme has been used on the new passenger locomotives for the Chicago, Milwaukee and St. Paul, built by the Westinghouse Co. A stabilizing resistance is used, which causes the field current in the motor (act-

ing as a generator) to vary inversely as the regenerated current so that sudden changes in line voltage do not affect the motor, but it is protected. The excitation of the motor fields during regeneration is not taken from a motor generator set, but from a generator driven from one of the axles of the leading truck. The use of the stabilizing resistance and axle-driven generator has advantages over other schemes, which will be explained. The connections when regenerating are shown by Fig. 1. Let us assume that the motor is regenerating. Current is then flowing through the motor armature *A* back into the line, and in order to have the circuit completed an equal current must flow back from the running rails through the ground connection, through the stabilizing resistance to the motor armature. With this regenerated current flowing there is a certain *IR* or voltage drop in the stabilizing resistance. It will be noted from the diagram, Fig. 1, that the armature of the axle generator is not connected directly to the motor field *F*, but that the stabilizing resistance *R* is also in the circuit. The excitation of the axle-driven generator is sufficient under these conditions to generate voltage in the armature *G* such that sufficient current will flow through *F* to give proper motor voltage for regenerating. The amount of current in this circuit depends on the voltage of *G*, the resistance of the motor field *F* and the *IR* drop in the resistance. The automatic feature functions as follows: Suppose that the line voltage suddenly drops. Immediately the motor armature *A* would deliver more regenerated current. This increased current returning through the stabilizing resistance increases the *IR* drop, or, in other words, the voltage across *ab* has

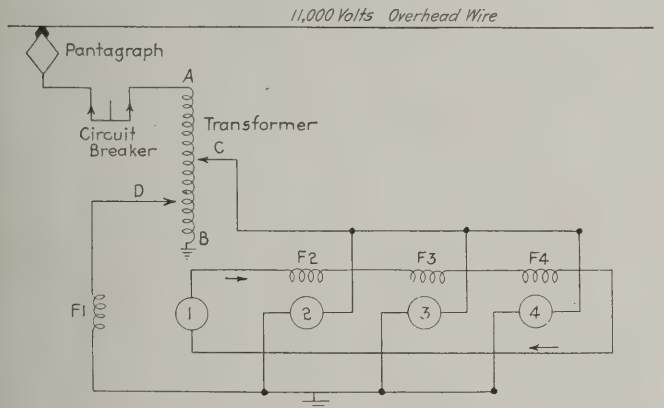


Fig. 2—Diagrammatic Connections for Regeneration With Single Phase Alternating Current Series Motors

increased. Since the voltage from *G* has not changed the current through the motor field must be decreased, and with the decreased excitation the voltage of *A* must decrease and the regenerated current therefore is decreased. That is, the arrangement as shown is automatic and the motor is protected. The reverse is also true. If the voltage suddenly rises, less regenerated current flows, the *IR* drop is reduced, more current flows in the field *F* and the motor voltage is raised, tending to maintain the regeneration.

With the axle generator, as the speed of the locomotive increases, due to a change in grade, the voltage increases and the excitation of the main field *F* is increased. This will increase the regenerated current, but the *IR* drop will increase and the excitation will be reduced. A new balanced speed will be set up automatically.

If four or more motors are mounted on the locomotive a wide variation of speed during regeneration can be obtained by combining the motors in the parallel and series connection in the reverse manner to that which is done when the locomotive is motoring. For instance, during acceleration the motors of the locomotive are operated in combination, starting, in the case of the four-motor equipment, with the four motors in series, then transferring the two motors in parallel, and two of these parallel sets in series, and finally to the four motors in parallel. Three running speeds are thus possible with these combinations, say, in the case of a freight locomotive, 8 miles an hour, with four motors in series, 16 miles an hour with the second arrangement, and 32 miles per hour with all four motors in parallel.

When regenerating with the locomotive running at a speed of approximately 32 miles per hour the motors would be used as four in parallel, and as the train speed decreases to 16 miles an hour the combination would be changed over into two in parallel and two in series and with further reduction in speed the motors would be connected four in series. The reason for changing the combination is apparent from the following: As the train is reducing its speed the control must be such that more current is passed through the fields of the motors which are generating so as to keep the valtage up above the line voltage. We know that a certain number of lines of force must be cut during a certain time to give the voltage necessary. The reduction in speed cuts down the rate in the cutting of these lines of force, so that it is necessary to increase the number of lines in order that the total number of lines cut will remain the same. Of course, there is a limit to the lowest speed, below which point it is not possible to keep up the field strength, hence the voltage would decrease below the line voltage and regeneration would stop unless the motors were put into the second combination. With the second combination we have two motors in series, the voltage of each motor being added together to force current against the line voltage. In the final arrangement under regeneration, namely, with four motors in series, all four voltages are added together to oppose the line voltage. It is analogous again to the water system, where, in the case of a double acting pump or compressor, the air pressure or water pressure obtained from the first system passes into a high pressure cylinder where it is increased to a much higher pressure by the movement of the second piston.

Regeneration with the single phase series commutating motor system, is possible and it is interesting to see just how this is accomplished. The single phase system uses a higher voltage for the overhead wire, usually 11,000 volts. Transformers are used on the locomotive to reduce this high voltage to a voltage suitable for the operation of the motors, taps being taken out at the proper voltages. A diagrammatic sketch for regeneration with a single phase series commutator type of locomotive is shown by Fig. 2. For regeneration connections and circuits the motor generator set can be used as in the direct current arrangement if desired, but another satisfactory arrangement for alternating current single phase operation is one where one motor of the four on the locomotive is used as a generator for furnishing current to excite the fields of the other three: the three motors sending power back into the line. Referring to the diagram, motor *No. 1* is used as a generator and furnishes current

to the field *F2, F3* and *F4*. The corresponding armatures generate current which is put back into the transformers through the lead *C*.

As the speed of the locomotive decreases the voltage from the motors can always be kept at a sufficient value to regenerate by putting more current to the field of these motors. This is accomplished by increasing the strength of the field of the *No. 1* motor by connecting the lead *D* to a suitable voltage tap either higher or lower. Moreover it is possible to still further get additional variation by moving of the lead *C* to higher or lower tap so that the voltage can be maintained slightly above the line voltage over a wide range of train speed. For convenience the transformer has been shown as an auto transformer, one end *A* of which is connected to the 11,000 volts and the other *B*, to ground. With a certain voltage at *C* generated by the motors Nos. 2, 3 and 4, the voltage can be increased at *A*, depending on the ratio $\frac{AB}{CD}$.

We have seen that it is possible to regenerate with both the direct current and single phase systems, providing that certain changes in the motor connections are made to give the necessary shunt characteristics and some means provided for exciting the shunt field. In both cases the inherent working principle is in maintenance of the voltage or electrical pressure of the regenerating machine higher than that of the distributing system to which it is connected. If the voltage of the distributing system could be kept constant regeneration with direct current would be simplified. But in railway service there are varying conditions, due to the movement of trains and the variation in grades and curves. Regeneration with direct current works very satisfactorily. But as far as simplicity and reliability are concerned the locomotives driven by the three phase motors are superior.

Regeneration with Polyphase Motors

The polyphase motor is a constant speed type and its speed does not depend upon the voltage of the circuit but upon the frequency of the power supply. Therefore for a given frequency there is a certain motor speed known as the synchronous speed. Alternating current does not give a constant pressure like direct current, but changes in value. Starting at zero it progresses to a maximum, then decreasing to zero, reverses, goes to an equivalent negative maximum and returns again to zero; all this takes place in a fraction of a second.

The induction motor consists of a stationary winding which is continuous on the inside of the motor frame, and a rotating armature. This armature has no connection whatsoever with the stationary winding or with the power supply circuit, the power being connected to the stationary winding on the frame. When the power supply is connected to the winding around the frame or stator a magnetic field is produced which rotates in this winding at a speed depending upon the frequency of the supply circuit and upon the number of poles of the motor. The revolving field passes by the winding on the armature, known as the rotor, induces a current in it which tends to stop the rotation of the field. As the rotating field cannot stop, the rotor is dragged along at practically the same speed, there being a slight slip, depending upon the load or the work which the motor is doing.

When regeneration takes place the rotor runs at a speed slightly above the synchronous speed of the stator field. For this reason and because the electrical supply is still connected to the primary winding of the stator, the rotor conductors overtake and therefore cut the lines of force of the revolving stator field, and current is generated in the rotor winding in the opposite direction. The rotor flux created by the reverse current flowing in the rotor affects the flux in the primary or stator winding and generates in them a flux to oppose rotation. The reversal of the flux in the primary causes a reversal of the primary current and hence power is delivered to the line. At the same time the rotor flux tends to bring the rotor speed back to that of the magnetic field and therefore offers resistance and supplies the necessary energy of braking effort to hold the motors on the grade. Tests show that practically as much power or torque is required to run the motor a given number of r. p. m. above the synchronous speed as the force which the motor will overcome when it is running as a motor the same number of revolutions below the synchronous speed. It is, therefore, not a question of generating a voltage to overcome the trolley voltage, as in the case of the direct current system, but it is purely a question of speed of rotation and a condition which takes place automatically without any change in the motor circuit. In fact, it is possible, and moreover the general practice, to leave the power on when the train starts on the down grade and when the speed of the train tends to be higher than the synchronous speed of the motors, regeneration automatically occurs.

The advantages gained by the use of the regeneration principle are many and are important advantages. They can be classified as follows: 1. *Brake shoes and wheels.* The energy stored up in a heavy freight train descending a grade is large, and with only air brakes available this energy must be dissipated as heat at the brakeshoes. Rapid wear of the shoes results, and the wheels are subjected to heavy wear and over-heating, with the risk of loose and broken tires and rims. The elimination of practically all of this dissipation of heat will result in reduced maintenance cost for the wheels and brakeshoes.

2. *Air brakes, brake rigging and draft gear.* These items are subjected to severe strains, so that regeneration results in a reduction of maintenance. The saving in the maintenance of rolling stock will be considerable.

3. *Power house.* Regeneration results in the saving in horsepower output, depending, of course, upon the operating conditions and the grades encountered. The saving in power consumption may be from 10 to 15 per cent in the ordinary service over mountain grades.

4. *Speed down grade.* The speed of a heavy train down the grade is often limited by the permissible heating of the brakeshoes, so that with regeneration the speed can be the safe speed for the track, curves and construction of the roadbed, if it is so desired. Higher speeds are permissible in descending the grade.

5. *Safety.* Safety of operation is one of the greatest advantages. The train is under better control and possible accidents are eliminated resulting from loose tires.

6. Last but not least are the results obtained from operation. Regeneration gives more uniform operation of trains. Longer and longer trains must be used as the transportation system grows, and with these longer trains it becomes more and more necessary to operate at a constant speed.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Chas. W. T. Stuart

VI.—Edison Trainlighting Storage Batteries

THE Edison storage battery differs widely from all other types in theory and characteristics. It has an alkaline instead of an acid electrolyte and the active materials are nickel oxide and iron instead of lead peroxide and spongy lead.

It is interesting to glance over a few points in the history of the storage battery that led up to this particular invention. From the beginning until the present

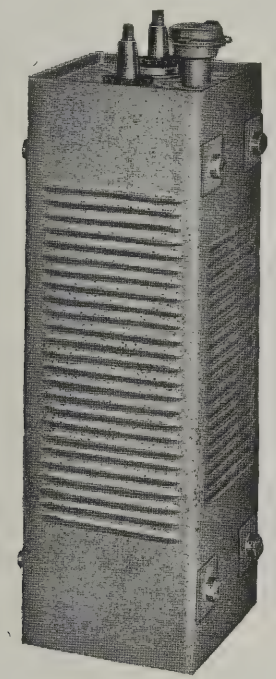


Fig. 1—Type A-8-H Edison Cell Complete, Showing Corrugations in Containing Vessel

time the aim of each inventor has been to produce an electrolytic cell in which electrical energy may be stored as chemical energy until ready for use. This cell must return at any time all or any part of the electrical energy put into it. It must also be in its original state when completely discharged.

In 1801 Gautherot discovered that silver or platinum wires used for decomposing water by the passage of an electric current would send the current in a reverse direction when placed on discharge.

In 1834 Faraday discovered that lead peroxide deposited by acetate of lead would give a current in the opposite direction from that originally causing the decomposition.

In 1854 Sinsteden discovered that plates of lead, silver and nickel in a voltameter would produce reverse currents.

In 1860 Plante discovered two sheets of lead separated and immersed in acid would send a current in a reverse direction when discharged.

In 1881 Charles H. Brush, in America and Camilla A. Faure, in France, independently produced the lead battery pasted plate.

In 1908 Thomas A. Edison, after years of study, placed the nickel-iron alkaline storage cell, Fig. 1, on the market.

Railroad Service

Train lighting batteries must be so designed that they will operate and give service under railroad conditions.

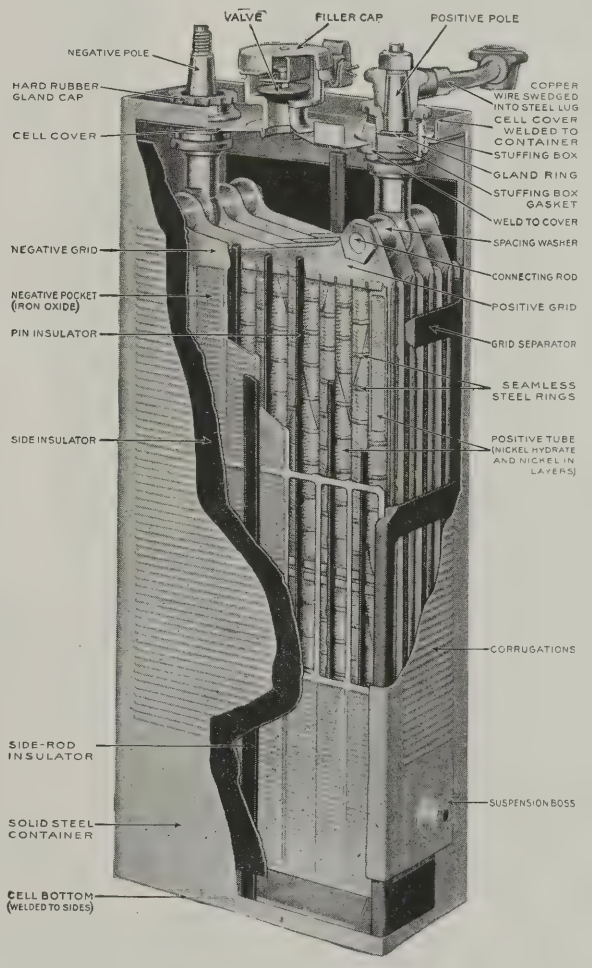


Fig. 2—The Edison Alkaline Storage Cell, Showing the Various Parts

This means that the battery must withstand rough handling, due to the bumping of the cars, etc., that it must stand a wide range of temperature due to climate and also be able to overcome an unlimited amount of neglect, such as remaining in a discharged condition for

long periods, etc. For these reasons the Edison storage battery is well suited for train lighting. It is free from the ordinary storage battery diseases and is of a rugged construction. It may remain in a discharged condition for a long time without injury or be subjected to vibration and concussion.

The Edison storage battery does not contain a storage of electricity. The name storage battery suggests that electricity is stored in the battery, but this is not so. A chemical action is stored in the Edison battery which in turn produces electricity.

Train Lighting Sets

The Edison storage battery is a number of cells each of which is a unit consisting of the following main parts:

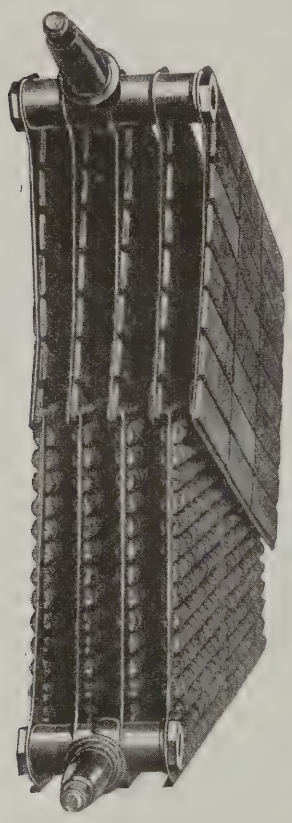


Fig. 3

Fig. 4

Fig. 3—Showing Method of Intermeshing the Positive and Negative Plates in the Process of Assembling a Cell Ready for the Container

Fig. 4—Type "A" Positive Tube Loaded With Nickel Hydrate, Ready to be Placed in Positive Grid. Note the 8 Seamless Rings Encircling the Tube

1. Containing vessel with cover.
2. Positive and negative groups of plates.
3. Electrolyte.
4. Insulators.
5. Connectors.

These parts are shown in Fig. 2. For train lighting there are six types. These are as follows:

Type A-4-H, rated capacity 150 ampere hours.
Type A-5-H, rated capacity 187.5 ampere hours.
Type A-6-H, rated capacity 225 ampere hours.
Type A-8-H, rated capacity 300 ampere hours.
Type A-10-H, rated capacity 375 ampere hours.
Type A-12-H, rated capacity 450 ampere hours.

The letter "A" in each type represents the size of the plates used. The number in each case represents the number of positive plates in each cell. The letter "H" indicates "High Type," as for train lighting the cells are assembled in higher containing vessels giving about three inches additional space for solution. This feature permits of working batteries for longer periods without adding water. Fig. 11 shows a 25-cell, type A-8-H battery.

Containing Vessel

The containing vessel, Fig. 2, is made of cold rolled, heavily nickeled, sheet steel, all seams being welded by

Fig. 5—Magnified Section of ¼-in. Tube. Light Layers Show Nickel Hydrate. Dark Vertical Lines Show Nickel Flake

the autogenous process, "oxygen-acetylene flame." The walls of the container are corrugated so as to give maximum strength with minimum weight. Bosses are welded on the sides to hold the cell in the tray and to keep the cells separated when they are connected up for service. The containing vessel cover is made of nickel sheet steel

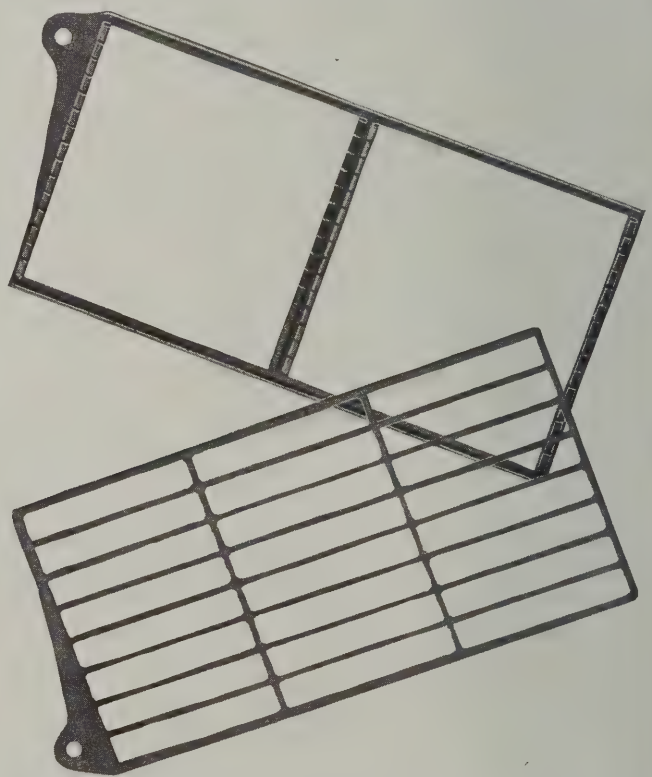


Fig. 6—Steel Grids into Which Negative Pocket and Positive Tubes Are Clamped by Hydraulic Pressure

and is welded on, after the elements have been placed in the containing vessel. The battery terminal poles pass through fittings in the containing vessel cover. These fittings are provided with soft rubber washers, and with rings and gland caps for expanding these rubber washers to form a gas tight and liquid tight packing between the top of the container and the poles. See Fig. 2. The

cover supports a combination filler cap and valve. The filler cap is operated by a spring which holds it wide open for filling or closed for operating, as desired. The valve is suspended from the under side of the filler cap

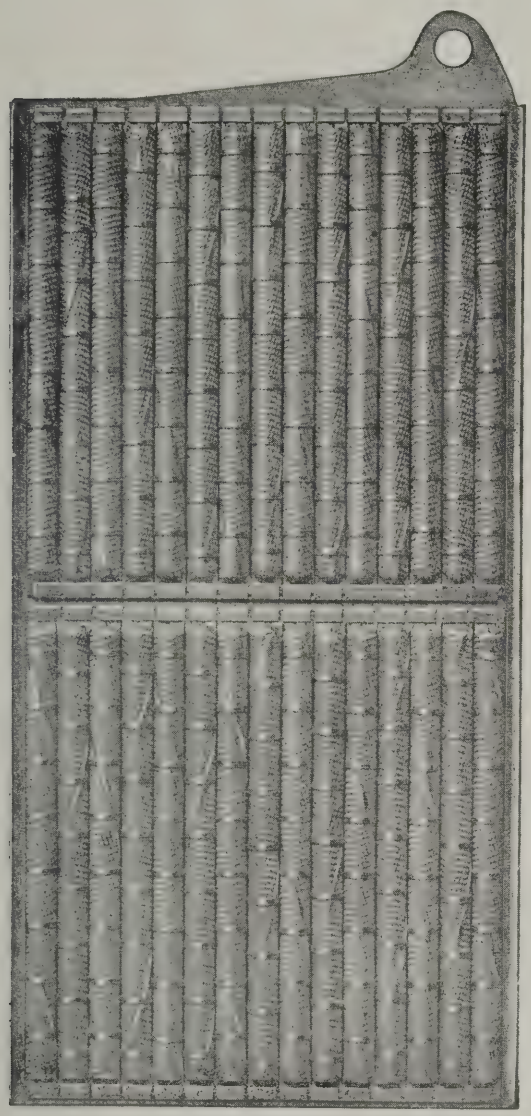


Fig. 7—Positive Plate Type "A"

and is so arranged that, as the gas pressure in the cell rises sufficiently to raise it, the escaping gas flows by and out under the filler cap. When the gas has escaped, the

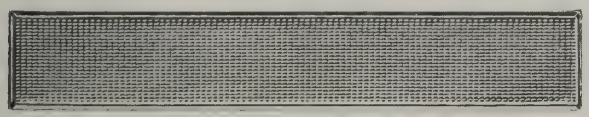


Fig. 8—Negative Pocket, Type "A" Loaded With Iron Oxide, 3 in. long, ½ in. wide, ⅛ in. thick

valve closes preventing any impurities from getting into the cell.

Groups of Plates

The positive plates are mounted on a steel connector rod with steel spacing washers and steel terminal post as shown in Fig. 2. The negative plates are also mounted on a steel connector rod with spacing washer and steel terminal post, Fig. 2. The positive and negative groups thus formed are intermeshed as shown in Fig. 3; being kept separate electrically by suitable rubber insulation, and are then ready to be slipped into the steel container.

Positive Plates

The active material of the positive plate is nickel hydrate, which is packed in thin layers under heavy pressure in perforated steel tubes, as shown in Fig. 5, which is an enlarged cross sectional view of a portion of one of the tubes. Between the layers of nickel hydrate are still thinner layers of pure nickel which appear as dark lines in the illustration. These metallic layers are made up of small flakes of nickel, each flake being about 1/16″

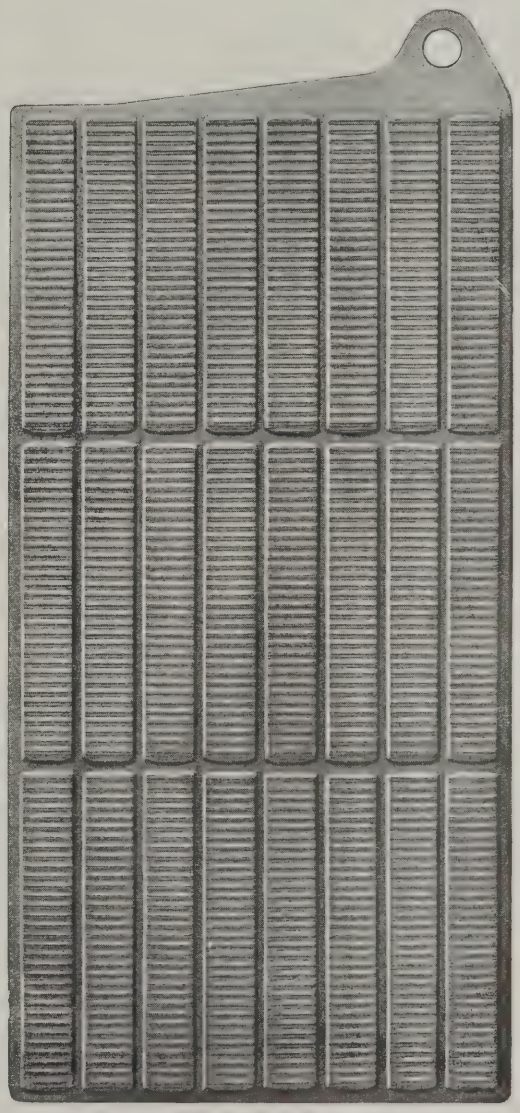


Fig. 9—Negative Plate, Type "A"

square and much thinner than tissue paper. During charge and discharge of the battery the passage of the electric current alternately oxidizes and reduces the nickel hydrate. The metallic nickel acts as a conductor, forming a path of low resistance to all parts of the active layers of hydrate. After the steel tubes are loaded they are strengthened by a number of encircling seamless steel rings, as shown in Fig. 4. Then they are mounted in a steel grid or frame, shown in the upper part of Fig. 6. The result is a strong positive plate as shown in Fig. 7. The type "A" positive plates are used in all train lighting cells. These plates are composed of thirty per-

forated nickel steel tubes arranged in two rows of fifteen each, as shown in Fig. 7. Each type "A" positive tube is ¼ in. in diameter, 4½ in. long and contains 700 alternate layers of nickel oxide and pure metallic nickel.

Negative Plates

The negative plate consists of a steel grid, shown in the lower part of Fig. 6, which supports a number of flat, perforated steel containers or pockets, Fig. 8. The active material is iron oxide, which is held within the pockets. The pockets after being placed in the openings of the grid are subjected to hydraulic pressure which forces them into permanent contact with the grid. The passage of current during the operation of the battery causes the active material of the negative plate to be alternately reduced and oxidized according as the battery is charging or discharging. The complete negative plate is shown in Fig. 9, which illustrates the type of plate used in train lighting batteries. It contains 24 pockets, arranged in three rows of eight pockets each. Each pocket is ⅛ in. thick, ½ in. wide, and 3 in. long.

Electrolyte

The electrolyte of an Edison battery is an alkaline and not an acid solution such as is used in a lead cell. An acid solution could not be used in an Edison cell because acid would act upon the nickel and steel electrodes. On the other hand, the alkaline solution preserves the steel and nickel and this in itself is a distinctive feature of the Edison cell.

The original electrolyte of the Edison cell is a 21 percent solution of potassium hydrate (caustic potash) to which is added a small amount of lithium hydrate. This solution has a normal specific gravity of 1.210 at 60 deg. F. which does not change over a long period. The specific gravity of a liquid is the weight of that liquid divided by the weight of an equal volume of water. During the war, the caustic potash supply was cut off and caustic soda was substituted, which has a normal specific gravity of 1.175 at 60 deg. F.

Separators-Insulation

The alternate positive and negative plates are insulated from each other by vertical hard rubber pins or rods, equidistantly placed. Moulded hard rubber "ladders" secure the plates at their edges and insulate the whole from the containing can. A sheet of hard rubber is placed between the end negatives and container. A moulded hard rubber "stool" forms the bottom support for the plates, see Fig. 2.

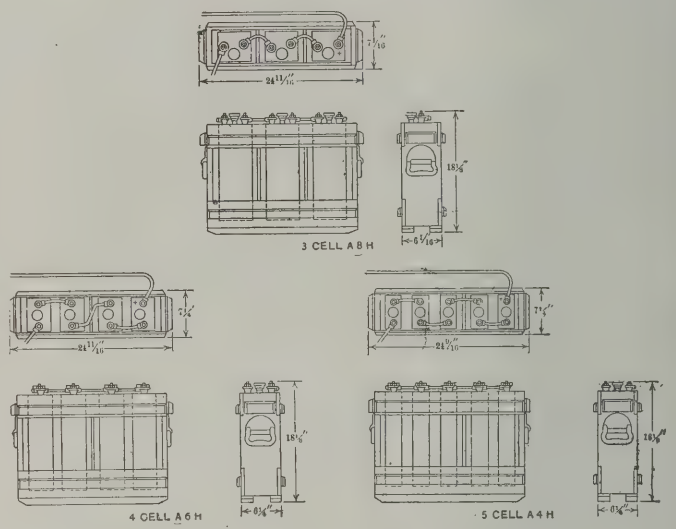


Fig. 10—Assembly of Edison Cells in Trays

Trays

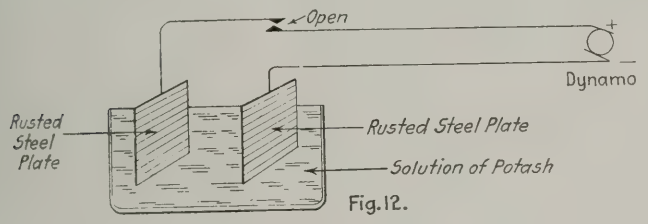
The cells are mounted in wooden trays as shown in Fig. 10, being supported either by a steel cradle and hold-down straps or by rubber buttons imbedded in the tray slats. In the latter case the cells are provided with steel bosses which fit into the rubber buttons in the tray slats. These supports maintain the cells in position even when subjected to violent concussion. The trays are designed to contain any desired number of cells to suit

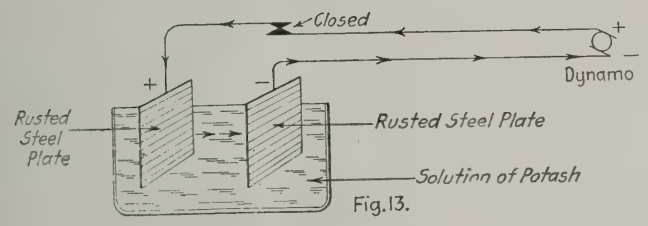
Fig. 11—Edison Train Lighting Battery, 30-volt, 300 Ampere-hour Capacity, 25 Type A-8-H Cells

different conditions. In most cases the A-8-H battery is assembled three cells to a tray while the A-6-H is assembled four cells to a tray and the A-4-H five cells to a tray, as shown in Fig. 10.

Connectors

The individual cells in the tray are connected together positive to negative by means of copper connecting links. The end cells in adjacent trays are connected together, positive to negative by means of insulated copper wire jumpers. The links and jumpers are provided with steel terminal lugs which are bored, reamed, and ground to





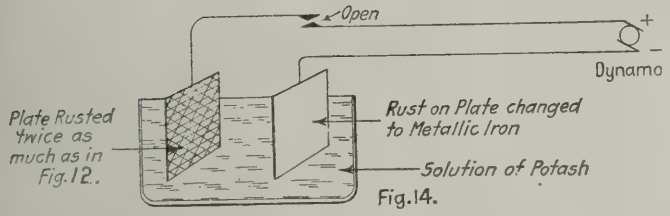


Fig. 12—Two Rusted Steel Plates Immersed in Solution of Potash and Connected by Two Wires to Dynamo

Fig. 13—Current Flows from Dynamo Through Solution, from One Plate to the Other and Back to the Dynamo as Shown by the Arrows

Fig. 14—Result of Charging as Shown in Fig. 13

fit the tapered top of the terminal posts. The terminal lugs are brought into intimate contact with the terminal posts by tightening the nuts on top of the terminal posts.

Theory

The Edison theory is totally different from that of all other storage batteries based upon either the Plante or the Faure theory. These latter use lead peroxide or spongy lead in an acid electrolyte, while Edison chose nickel hydrate for the positive active material of his battery, iron oxide for the negative active material, and an alkaline electrolyte.

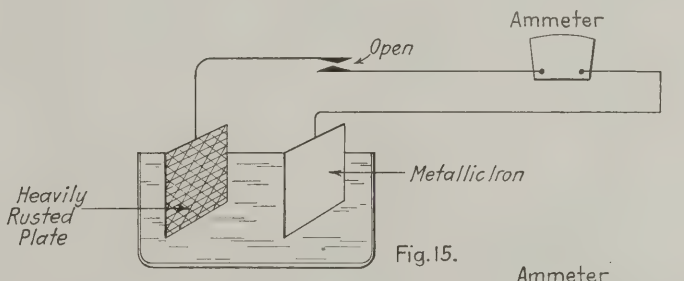
A few points that lead up to the perfection of the Edison battery may be interesting and should enable the reader to grasp the theory more quickly.

If two pieces of very thin bright steel were placed out of doors for a few weeks they would rust. This means that the oxygen in the air has acted on the outer layer of the metal and formed an oxide commonly known as rust. Next place these two pieces of steel in a solution of potash and water, and connect them by wires to a small dynamo, as shown in Fig. 12. The electricity, in flowing from the dynamo through the solution, from one of the plates to the other and back to the dynamo as shown in Fig. 13, changes the rust to metallic iron on one of the plates, but causes the other plate to become rusted twice as much as before, see Fig. 14.

Now disconnect the plates from the dynamo and connect them, by means of pieces of wire to an ammeter, as shown in Fig. 15. Instantly, the excess of oxygen in the rust on the plate commences to pass back to the bright plate and by so doing, causes the electricity to be generated, Fig. 16. Why? Nobody really knows.

We have now charged and discharged a primitive storage battery. Instead of two thin rusted steel plates, let us mount, say, one hundred such plates, equidistantly spaced on one rod, and one hundred more on another rod. Now interpose the two groups so that the plates of one group will not touch those of the other and immerse them in a solution of potash. When connected to our dynamo the electricity will flow from one group, through the solution, to the other group, converting the oxide of one group to metallic iron and increasing the amount of oxide on the other group. We shall be able to get much more electricity from the battery thus formed, because of the greater plate surface exposed.

We have thus determined that large surface is necessary. Let us next place a quantity of fine particles of iron rust in two perforated flat steel pockets, and after putting these pockets into potash solution pass electricity from one to the other, through the solution as before. All the iron rust in one pocket will be changed to metallic



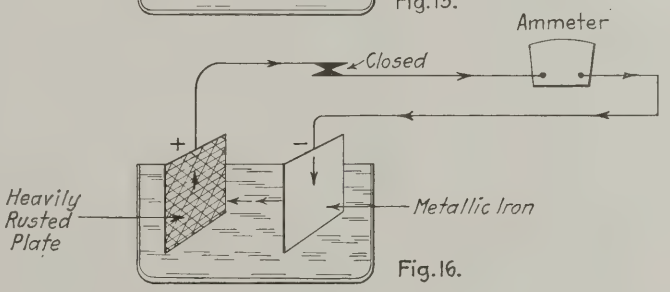


Fig. 15—Plates Disconnected from Dynamo and Connected to Ammeter

Fig. 16—Current Flows as Shown by Arrows

iron, because the oxygen will have passed over to the iron rust in the other pocket, causing this material to possess twice as much oxygen as before.

Connect the two pockets to an ammeter and you will find that much more electricity is flowing than before, although the two pockets take up much less space than the two hundred steel plates. The reason of this is, the small particles present a very great combined surface to the solution.

Suppose after having made a great number of experiments you put some iron rust or iron oxide into perforated steel pockets, and mount a number of these

pockets in a steel grid or support to form one plate, and place nickel hydrate (a green powder) in perforated steel receptacles and mount them on another grid to form another plate, then immerse the whole in a solution of potash, you will have arrived at the point Edison reached when he invented the Edison storage battery.

Chemical Action of an Edison Cell

As it is chemical energy that is stored in the battery and not electricity, it is necessary when explaining the action that takes place in the battery to include chemical symbols and equations. Therefore an explanation of a few terms may help those who have not studied chemistry.

The symbols for the elements which will be used are as follows:

Elements	Symbols
Hydrogen	H
Oxygen	O
Potassium	K
Nickel	Ni
Iron	Fe

The elements are combined into the following:

The formula for nickel oxide is NiO_2 meaning that nickel and oxygen are combined to form nickel oxide. The formula for water is H_2O meaning that hydrogen and oxygen are combined to form water. Iron oxide is Fe_3O_4 indicating that iron and oxygen are combined to form iron oxide, and potassium hydrate is KOH signifying a combination of potassium, oxygen and hydrogen.

The fundamental principle of the Edison storage battery is the oxidation and reduction of metals in an electrolyte which neither combines with nor dissolves either the metals or their oxide. Also, an electrolyte which notwithstanding its decomposition by the action of the battery is immediately reformed in equal quantity and is therefore a practically constant element without change of density or conductivity over long periods of time. Therefore, only a small quantity of such electrolyte is necessary, permitting a very close proximity of the plates. Furthermore it is unnecessary to take hydrometer readings until about three hundred cycles of charge and discharge have been made; this is simply to determine when it is necessary to empty out the old solution and put in new. The active material of the plates being insoluble in the electrolyte no chemical deterioration takes place therefrom.

The chemical reactions in charging the Edison storage battery are (1) the oxidation from a lower to a higher oxide of nickel in the positive plate and (2) the reduction from ferrous oxide to metallic iron in the negative plate. The oxidation and reduction are performed by the oxygen and hydrogen set free at the respective poles by the electrolytic decomposition of water during the charge. The charging of the positive plates is therefore simply a process of increasing the proportion of oxygen to nickel. The proportion of nickel to oxygen in the various oxides of nickel are as follows:

	Atomic Proportions		By Weight	
	Ni	O	Ni	O
NiO	1	1	1	.273
Ni_3O_4	1	1.33	1	.364
Ni_2O_3	1	1.5	1	.409
NiO_2	1	2	2	.545

The relative amounts of oxygen necessary to oxidize nickelous oxide, or NiO, which is the oxide corresponding to the green nickel hydrate used in making the battery, to the various oxides are given in the three reactions.

(1.) $6\ NiO + 2\ O = 2\ Ni_3O_4$
(2.) $6\ NiO + 3\ O = 3\ Ni_2O_3$
(3.) $6\ NiO + 6\ O = 6\ Ni\ O_2$

The NiO_2 is capable of reacting with NiO according to the reaction $Ni\ O_2 + Ni\ O = Ni_2O_3$

Ni_3O_4 is considered as a combination of NiO plus Ni_2O_3. From a chemical standpoint a charged condition of the cell would, therefore, be represented in the positive plate by an atomic ratio of nickel to oxygen of at least 1 : 1.5 (or Ni_2O_3, depending on the charge. A discharged condition would be represented by a ratio of

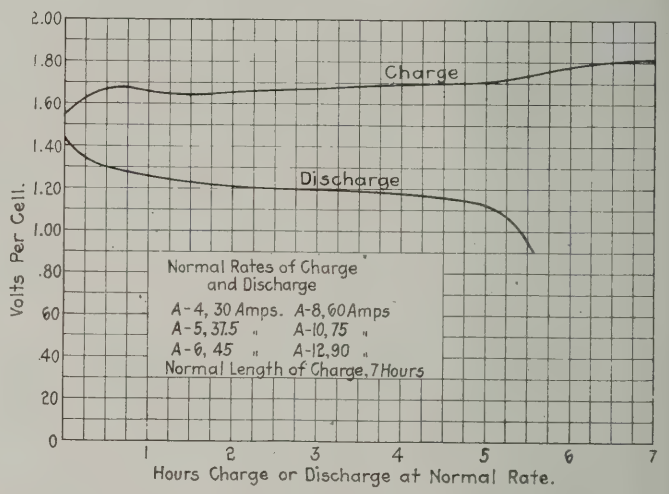


Fig. 17—Normal Charge and Discharge Voltage Curves of Type "A" Cell

1 : 1.33 (Ni_3O_4) or lower, depending on the discharge. The discharge of a cell is simply the reversal of the above reactions, the hydrogen reducing the higher oxides of nickel to lower oxides and the oxygen oxidizing the iron to ferrous oxide.

A Complete Cycle in a Simple Form

The following explanation of the chemical action may be more easily understood by those who are not so familiar with chemistry. Starting with iron oxide in the negative, green nickel hydrate in the positive, and potassium hydrate in the solution, the first charging of the cell reduces the iron oxide to metallic iron while converting the nickel hydrate to a very high oxide, black in color.

On discharge the metallic iron goes back to iron oxide and the high nickel oxide goes to a lower oxide, but not to its original form of green hydrate.

On every cycle thereafter the negative charges to metallic iron and discharges to iron oxide, while the positive charges to a high nickel oxide. The current passing in the direction of charge or discharge, decomposes the potassium hydrate of the electrolyte, and the oxidation and reduction at the electrodes are brought about by the action of its elements. An amount of potassium hydrate equal to that decomposed is always reformed at one of the electrodes by a secondary chemical reaction and the consequence is, there is none of it lost and its density remains practically constant.

The eventual result of charging, therefore, is a transference of oxygen from the iron to the nickel electrodes, and that of discharging is a transference back again.

This is why the Edison is sometimes called the oxygen lift cell.

The above action on discharge may be approximately represented by the following equations:

Positive—8 K + 6 NiO_2 equals 2 Ni_3O_4 plus 4 K_2O.

Negative—8 O H plus 3 Fe equals Fe_3O_4 plus 4 H_2O.

The reverse reactions take place on charge. The iron and nickel compounds are probably hydrated but are here treated as oxides for the sake of simplicity. It will be noticed that the same amount of K O H is decomposed according to the left hand members of these equations as is reformed simultaneously as shown on the right. For this reason the chemical composition or specific gravity of the solution does not change appreciably throughout the cycle of charge and discharge.

Capacity and Charging Rates

The following table shows the capacity, normal discharging and charging rates, etc., for the various types:

Type						
Capacity, amp. hrs.	150	187.5	225	300	375	450
No. of positive plates	4	5	6	8	10	12
No. of negative plates	5	6	7	9	11	13
Charging rate, 7 hrs., amps.	30	37.5	45	60	75	90
Discharge rate, 5 hrs., amps.	30	37.5	45	60	75	90
Discharge rate, 8 hrs., amps.	18.75	23.4	28	37.5	47	56.25
Average discharge voltage per cell	1.24	1.24	1.24	1.24	1.24	1.24
Average discharge voltage 25 cells	31	31	31	31	31	31
Average discharge voltage 50 cells	62	62	62	62	62	62
Weight of single cell, lbs.	16.3	19.4	22.6	30.7	38.3	46.9
Weight of 25 cell battery, lbs.	485	563	643	863	1,150	1,350
Weight of 50 cell battery, lbs.	970	1,125	1,285	1,725	2,300	2,700
Height of solution above plates	3″	3″	3″	2¾″	2¾″	2¾″
Cell container dimensions, length	2.60″	3.23″	3.81″	5.06″	6.19″	7.37″
Cell container dimensions, width	5.12″	5.12″	5.12″	5.25″	5.50″	5.50″
Cell container, dimensions, height	15.00″	15.00″	15.00″	15.25″	15.25″	15.38″

The range of voltage during a normal seven hour charge is from about 1.6 per cell minimum to 1.8 maximum.

The range of voltage during a normal five hour discharge is from about 1.4 per cell maximum to 1 volt per cell minimum.

Fig. 17 shows normal charge and discharge voltage curves of a type "A" train lighting Edison cell.

The Testing of Welds in Steel Plates*

Conditions Which Affect Quality of Welds; Simple Bend Test and Etching of Sections Recommended

By S. W. Miller
Rochester Welding Works, Rochester, N. Y.

THERE have been many failures of welds in the past, some not explained and some very expensive. As in all other developments, welding first received its principal impetus from the practical man. Of late, however, the tendency has been to investigate more carefully and more fully and by means not available to the ordinary welder. This means that scientists of all kinds have been called into consultation and that almost every conceivable method of test has been suggested in order to determine what methods and materials would make the best welds both from a standpoint of security, service and cost. While some of the methods employed at present are beyond the reach of the ordinary welding shop, yet they are of great value and, in fact, necessary in order to determine correctly what has occurred during the welding operation and what results may be expected under given conditions. Most of the published results are incomplete in one or more respects and one of the objects of the American Welding Society is to put the testing of welds and welded structures on a firm and safe foundation.

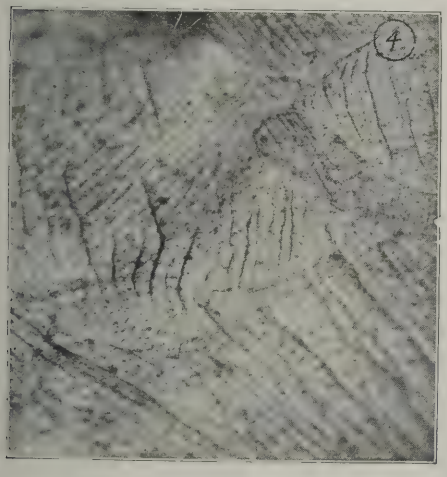


Fig. 1—Strained iron. The curved lines are not cracks, but the edges of parts of the grains that have slipped past each other. They are called slip bands.

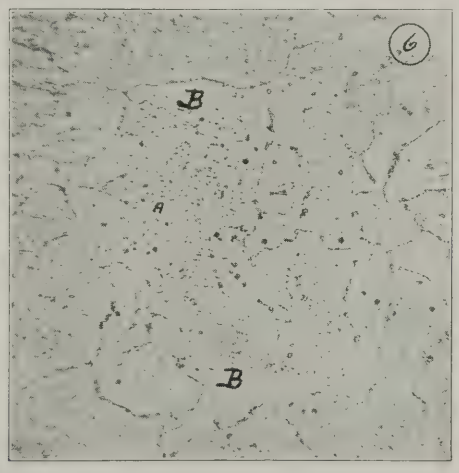


Fig. 2—A good looking oxy-acetylene weld, but made with too large a tip, as shown by the short straight lines in some of the grains.

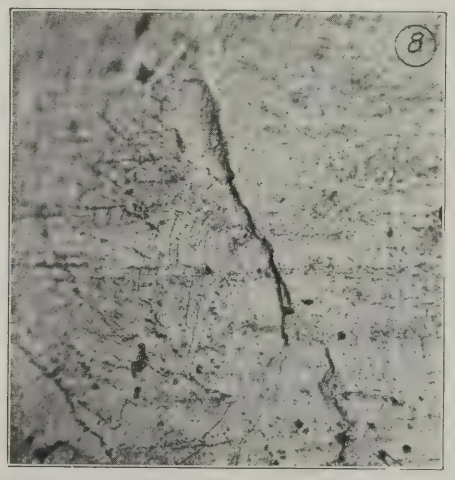


Fig. 3—Oxy-acetylene weld showing heavy slipping at grain boundary. This is not a crack, but shows a weakness.

Common Methods of Testing

The testing of metals, aside from welds, is quite well developed both in theory and practice. The usual test is

*A paper read before the September meeting of the Chicago Section of the American Welding Society.

the tensile test that gives the tensile strength per square inch, the yield point or elastic limit in pounds per square inch, the elongation in per cent of the original gage length and the reduction of area in per cent of the original section. Compression, torsion, shock and alternating stress tests are also used and the two latter are beginning to be used much more than they have in the past because it has been found that materials may give high results in the tensile test and yet be entirely unsuitable to resist service where shock or alternating stresses are met. Another of the common tests is bending to a certain radius either hot or cold and it has been found that it is a very valuable test of certain qualities.

Chemical analysis is another powerful method of investigation and many specifications have been made in which its use is vital.

The microscope has been found to be of tremendous help in the study of metals and, in fact it is now a necessary instrument in all laboratories. Its principal function is to determine the extent and location of impurities in a metal, to decide whether the structure is proper for the purpose desired and to decide whether various heat treatments will give satisfactory results. While no one method of test shows everything desired to be known, the microscope is probably the most powerful single method of investigation in the case of metals, and in the study of welds it is particularly valuable because of the method sometimes considered that steel is steel and that no different treatment is required in the case of different qualities and varieties of steel. This idea is much less common today than it was several years ago, but it is still too prevalent for the good of the art. A comparatively small difference in the percentage of carbon in the material being welded makes a very great difference in the results of either a bend or tensile test. If the carbon is .12 per cent or less, the material is soft, ductile and yields readily to any strain that may be put on it. Such material is frequently used for tanks, and because of its ductility and comparative freedom from damage by heating, is admirably suited for welding. Structural steel, bar steel and boiler plate contain about .15 per cent to .25 per cent carbon and have a tensile strength of about 60,000 lb., while the soft low carbon material has only about 52,000 to 55,000. Ship plate is required to have a tensile strength of from 58,000 to 68,000 lb. and in order to secure this characteristic the heavier sections require as high as .30 per cent carbon.

It has been found by experience that the higher the carbon the more difficult it is to get a satisfactory weld and the more danger there is of injuring the metal being welded. From a metallurgical point of view this is entirely natural and to be expected. It is also evident that a weld made with a given welding rod or electrode can have only a given strength. If this strength is greater

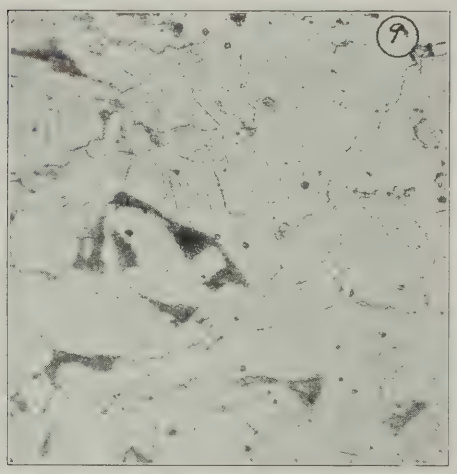


Fig. 4—Good oxy-acetylene weld made with rather high carbon steel. Note presence of slip bands as in all good welds.

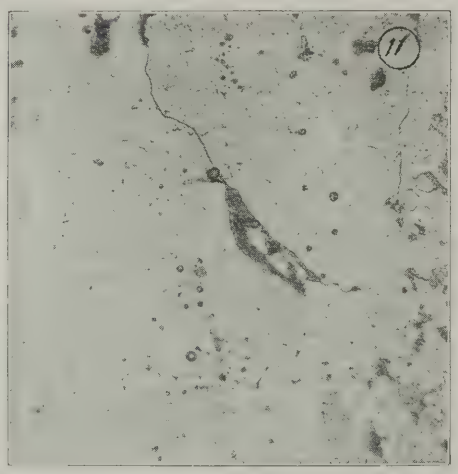


Fig. 5—Film of foreign matter, probably oxide, in oxy-acetylene weld.

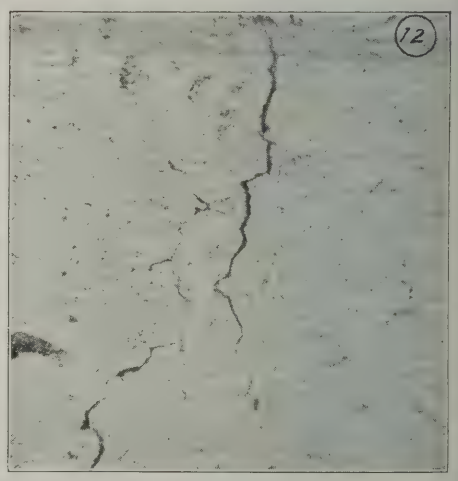


Fig. 6—Inter-granular cracks in strained oxy-acetylene weld. No defects visible before straining, showing that films were very thin.

of their formation. A weld is a casting and is subject to all the defects found in castings, which are, however, exaggerated in the case of welds.

Welds in Steel Plates Only Considered

This paper is confined to defects in the welding of steel plate by the oxy-acetylene and metal electrode processes. The welds considered are those in some important structure where soundness and high quality are necessary. By soundness, I mean freedom from mechanical imperfections such as lack of fusion, the presence of films or other inclusions, gas pockets, slag, etc. Welds of inferior quality may answer some purposes admirably, and if they do, there is no use in making better ones, but this is not the goal at which to aim for one who desires to make really good welds. The welding of steel is frequently considered as not being especially difficult, and it is also

than that of the material being welded, the test piece will always break outside of the weld. If, on the other hand, the weld is weaker than the material being welded, the rupture will always take place in the weld. An oxy-acetylene weld made with ordinary low carbon welding wire will have a tensile strength of about 52,000 lb. This is stronger than soft tank steel and weaker than the other materials mentioned. It is possible to get with alloy steel rods of proper composition a tensile strength in an oxy-acetylene weld of about 50,000 lb. Neither of these materials will weld boiler steel, boiler plate or ship plate, so that the rupture will occur outside the weld when the section of the weld is the same as the section of the piece. Therefore, in making tests of welded pieces, it is necessary to know accurately the character of the material being welded because, if Welder Jones makes a weld in soft tank steel and Smith makes one in bar steel, the first will

break outside of the weld and the latter in the weld, with a probable adverse criticism of Smith's work.

Recommended Physical Tests

The method of test to be applied in any given case depends largely on the use to which the welded piece is to be put. If it is to be used in a pressure vessel, I believe that not only should a tensile test be made but that an alternating stress test should be used because of the breathing of the tank due to changes of pressure. This latter test should also be applied where the weld is subjected to bending strain. There are no standards at present for weld tests, but it is advisable, whenever possible, to follow those of the American Society for Testing Materials. Inasmuch as a welded piece is not of uniform character, it is not possible to use the elongation and reduction of area as commonly measured. Where the break occurs in the weld, the elongation of the whole test piece tells very little about the quality of the weld, and I have been in the habit of taking the elongation in each inch, two inches, etc., of the gage length, beginning at the center inch, which includes the weld, and plotting these figures, against the gage length. Evidently, when the break is outside the weld, the various physical characteristics are those of the original material and not at all of the weld. The best test, in my opinion, to determine quickly the general character of a weld is to grind it off level with the surface of the pieces and clamp it on an anvil, with the center of the weld level with the top of the anvil, the bottom of the V toward the anvil so that the top of the weld is stretched when the projecting end is struck with a sledge. The blow should not be too heavy and the number of blows and angle to which the piece bends before cracking are quite a good index of the value of the weld. It is true in this test, as in the tensile tests, that the quality of the material being welded has a great influence on the results. Stiff material throws more of the strain into the weld, while soft ductile material will itself take considerable of the bend. In the case of defective welds, that is, those not fused along the V or which contain slag or other inclusions, this test will at once develop the defects. If a welded piece were to be used in a place where it might become red hot, such as, for instance, in a locomotive firebox crown sheet, it would be entirely proper to test the weld at a good red heat, and I believe that it would be of much interest to all of you, if you would test some of your welds by clamping them in a heavy vise or on an anvil with the center of the weld about half an inch from the edge of the table or above the face of the anvil, heating them to a bright orange with the torch and then bending them as before with a sledge.

If such welds are made in half-inch by two-inch bar steel, a 90-degree single V being used, and they bend to a right angle cold without cracking on the outside, a welder may feel well satisfied with his work.

Conditions Affecting Quality of Welds

There seems to be quite a definite relation between the thickness of metal, the size of tip and the size of the welding wire, in the case of gas welding, and between the thickness of metal, the diameter of the electrode, and the current used, in electric welding. It is also to be understood that electric welds, except possibly those made with covered electrodes, will not stand as much bending as oxy-acetylene welds.

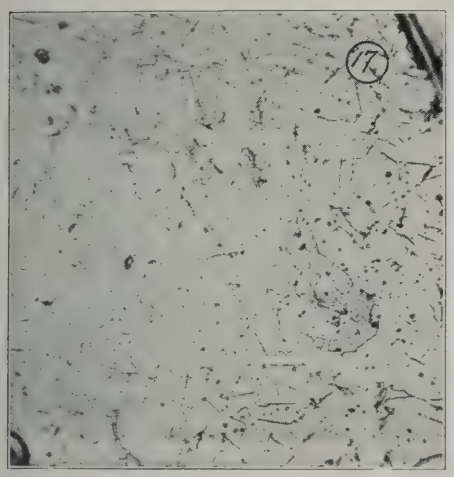


Fig. 7—Arc weld made probably with too long an arc, as there should not be so much iron nitride.

Fig. 8—Slip bands in arc weld. The heavier straight lines are iron nitride. These weaken the weld little, if any.

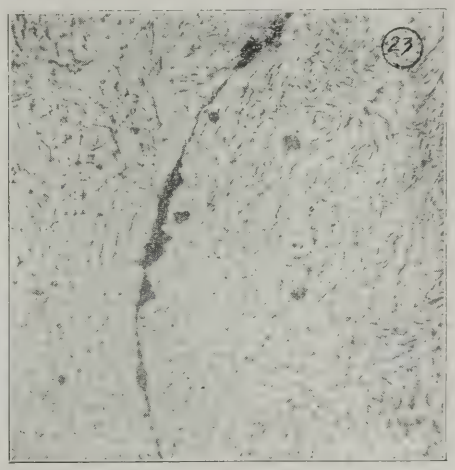


Fig. 9—Large defect in arc weld. Dark streak is oxide of iron.

In many cases, the defects in welds are easily visible to the naked eye when tested. In other cases, they are not, and while it would seem plausible that the visible ones were more dangerous, yet, to my mind, the hidden danger due to the ones that are hard to see is a matter that must not be overlooked. For many years, the dangerous defects in steel rails have been those which were not visible and which have usually been very small at the start. During the war, when the demand for gun steel was very heavy, flaky steel, so called, was the material that gave the government the greatest cause for concern. In fact, those who are best posted on the metallurgy of steel are paying more and more attention to the minor defects, which heretofore have been considered but of little importance. This is equally true in a case of welds; and in finding out what a welder can do, this is one of the things that should be examined most carefully. A method for testing rails for these hidden defects has recently been developed by F. M. Waring. It consists of deeply etching a polished surface of the material under test. For instance, a section of a weld might be cut out with a hack saw, machined or filed to a true surface, and

polished on various grades of emery paper, ending up with 00 Manning. It is then placed in a warm solution of 25 per cent hydrochloric acid and water for from half an hour to an hour. The acid will eat away the defects, making the edges of the material at them taper, so that rather large grooves and pits will be visible where the defects prior to the etching would be only microscopic. It is not really necessary to warm the acid, although it takes longer when it is cold. The bending test, hot and cold, and the etching test are of the greatest value in ordinary shop practice where it is desired to find out rapidly and quite accurately what the quality of the work done by the different welders is.

Effects of Strain

Some of the defects in welds are visible under the microscope, but others are not visible until the weld is strained. A small bending machine that can be placed on the microscope stage is very useful, because after etching, the piece can be bent and examined to see what the effect of the strain is. In the case of bare wire electric welds, the rupture, as far as my experience goes, always occurs at the grain boundaries, even where no defects are visible there at the highest powers of the microscope. Of course, where there are visible defects, the rupture takes place first at these. Where there are no defects, the distortion occurs by slipping in the grains as in normal steel. The causes of these defects are to my mind almost always oxides of one or another constituent of the metal, but usually of iron. There is no positive proof of this as yet, but there are indirect proofs. An electric weld that will bend very little may be made much more ductile by heating in a reducing atmosphere at a low red heat for one or two hours, indicating that the weakness at the grain boundaries has been removed. The reducing atmosphere would seem to make it clear that the material at the grain boundaries was on oxide. Again, heating an electric weld in an oxidizing atmosphere makes it more brittle.

These rough tests, while satisfactory for determining the general quality of the work, do not answer as a basis for design and more refined tests must be used as before referred to. I believe that the most important of these are the tensile and alternating stress tests.

Conclusion

A great deal may be learned from the appearance of a weld. It is difficult to describe the appearance of good welds, but after they have been seen a number of times, an inspector can readily say whether the operator knows what he is doing. In gas welding, I would not accept a ripple weld in heavy material nor one which was narrower than about 2½ times the thickness of the sheet, because I have never seen a weld having these appearances that was properly welded. The appearance of properly made electric welds has been well described by Mr. Escholtz of the Westinghouse Company and has been published in several of the trade journals. The appearance in a gas weld of porosities on top, indicates that the metal has been overheated, and the same thing is true in an electric weld. Inasmuch as I believe that the serious defects in welds are caused by oxides, it would appear wise in the case of gas welding to use no larger tip than is necessary to produce thorough fusion. This means that the catalogue speeds of welding are impossible if good welds are desired. The same thing is true of electric welds. The reason is that at the high temperatures of the steel caused by too large a tip or too heavy a current, the metal becomes overheated, and in that condition combines more readily with the oxygen of the air or with any excess oxygen in the torch flame, and produces oxides which are readily dissolved by the melted metal. As the metal cools down, these oxides are rejected in large part and pass to the grain boundaries, as do other impurities, so that it is perfectly natural that material which has been seriously overheated should be more brittle and weaker than the material which has been properly melted. I have found in a number of cases that very great improvements in the quality of the work were made by using regularly a bending test, and by carefully instructing the welders until their welds meet this test with unfailing regularity.

Electricity Used for Pumping

By C. R. Knowles
Supt. Water Service, Illinois Central Railroad.

While electricity has been employed to some extent as power for pumping at railway water stations for many years, its use has not been general. It has long been apparent that electricity had its advantages for this class of service, but up to the past few years current has not been available at many outlying stations, and where current was available the rates were often so high that there were but few places where electric power would show a saving in operation over steam or gasoline. Within recent years the production of electricity for commercial purposes has increased greatly and the extension of power lines has made it available at many points on our railroads at rates sufficiently attractive to warrant serious consideration, with the result that there has developed a considerable use of electric motor drive for pumping plants at water stations.

A motor-driven pumping plant with automatic pressure regulator or float switch control is specially suited to locomotive water tank service at many points because the tank may be kept full, regardless of variations in the demand for water, without any attention other than a periodical inspection of motor control and pump. It is also practical in some installations to have the station agent or local employee start and stop the pump by a remote control switch or push button. The standard control equipment now on the market is reliable and can be depended upon for pumping station service.

The cost of electric power for pumping is usually lower than the cost of the fuel that would be required by a steam plant, as the coal consumed at the average railway water station is from 4 to 6 times that necessary to generate the electricity required to pump the same amount of water. This is accounted for by the fact that with a steam plant there is a loss of fuel in getting up steam, banking fires, etc. Also as a general thing the pump in the average railway water station is not as efficient a machine as the large steam turbines commonly used in central power stations. Electric motor driven pumps have an added advantage over steam in lower first cost, and lower maintenance, while they are more compact, cleaner and easier controlled. An important factor in the comparative cost of a steam and electric plant is the housing. An electric

pumping plant will require a building approximately one-third the size of that required for a steam plant of the same capacity. On the other hand, the difference in the cost of pumping by steam and by electricity is offset to some extent by reason of the current having to be carried over a transmission line with resultant line losses, together with the cost of construction and maintenance of power lines. Electric power also has a disadvantage where pipes and pumps are exposed to freezing temperatures since it is necessary to provide some method of heating the plant and where extremely low temperatures prevail constant attendance is often required to keep it from freezing during the winter months. Another point to be considered is the question of electric service interruptions due to storms or other causes. While the motor itself is reliable and can be further protected against failure by installing duplicate units it is not a prime mover and unless more than one source of power is provided it is liable to failure through interruption of power supply. This is particularly true where the source of power supply is from a small or heavily loaded plant where trouble may be expected from variable voltage or frequency.

The development of the internal combustion engine using oil as fuel has been a factor in retarding the general use of electricity, as an electric motor can compete with the oil engine in operating costs only where the motor can be operated by automatic control, thereby eliminating the expense for constant attendance. The cost of current is usually based upon the nature of the demand as well as the amount of current used. A better rate may be secured where the load is uniform throughout the 24 hours than where the pumps are operated for only a few hours, and in many cases a still better rate for current may be obtained when the pumping hours are arranged so that the pumps may be operated on the off peak load. Contracts for electric power usually contain a charge dependent upon the aggregate horse-power of the motors as well as the stipulated charge for current. The charges for current are invariably based on a sliding scale of rates per kw., the lowest rate applying to the greatest consumption of power. Rates for current vary widely, depending on the size of the central power station as well as the location and class of equipment in the power station. Electric drive is adapted to all types of power pumps, especially the centrifugal type, as the motor can be connected direct to a centrifugal pump without belts or reduction gears.

The convenience and simplicity of a direct-connected motor and centrifugal pump make it one of the most desirable installations for tank service under conditions within the limits of centrifugal pump operation. Recent installations have consisted largely of this type of pumping unit, but failure to realize the limits of a centrifugal pump has unfortunately resulted in some unsatisfactory installations.

One middle western railroad has recently installed electric pumping equipment consisting of duplicate units, each having a capacity of 30,000 gal. per hour, the operation of the pumps being controlled by the height of water in the tanks. This plant replaced a steam plant which required the services of three men while the electric plant is operated by one. The cost for current about equals the cost of coal formerly used in the operation of the steam plant and the net saving is approximately $1,500 per year.

The pumps are two horizontal, single stage, double suction, split shell, centrifugal pumps with 5 in. suction and discharge openings, with bronze enclosed impeller and bronze fitted throughout. The pumps are designed to deliver 500 gal. per min. against 100 ft. total head, including 15 ft. suction head at 1,750 r.p.m., the mechanical efficiency being 66 per cent.

The motors are two 25 hp. horizontal, 3 phase, 60 cycle, 220 volt, 1,750 r.p.m. cross-the-line-type self starting motors. Motors and pumps are direct connected and mounted on the same sub-base. The control panel is of the Sundh type consisting of two overload time limit relays of the hand reset type, main line switch, phase protective relay, two-pole knife switch for hand operation, three-pole double throw knife, switch so wired that either motor may be operated but not the two together, double pole cross-the-line contactor for throwing the motor across the line and a Gage-type pressure regulator for operating panel by tank pressure. The pumps are fitted with a diaphragm by-pass valve for priming automatically when operating under automatic control.

The pumps have been in operation 9 months, during which time they have pumped 90,000,000 gal. of water at a cost of $1,523 for electricity, or $0.0169 per thousand gallons for power only, the power consumption being 47,870 kw.hr. at an average cost of $0.0318 per kw-hr., the total head ranging from 78 to 90 ft.

Operating Results by Months

Month	Electricity		Cost	Gallons Pumped
January	5,370 kw. hr.		$174.57	11,000,000
February	5,820 kw. hr.		168.98	10,100,000
March	5,650 kw. hr.		165.92	10,000,000
April	5,440 kw. hr.		162.14	9,150,000
May	4,940 kw. hr.		152.59	9,250,000
June	4,870 kw. hr.		151.12	9,000,000
July	5,430 kw. hr.		161.96	10,000,000
August	2,270 kw. hr.	$28.92		
August	2,260 kw. hr.	145.87		
			174.79	11,300,000
September	5,820 kw. hr.		201.71	10,200,000
Total	47,870 kw. hr.		$1,513.78	90,000,000

As an example of the comparative cost of pumping water with steam and gasoline the following figures show the results obtained at Dumont and Lake Mills, Iowa, on the C. & N. W. Ry. The installation at Dumont consists of a 5 in. by 6 in. triplex pump driven by a 3 hp. 220 volt, 60 cycle, 3 phase, 1,150 r.p.m. motor, direct connected to the pump. The average consumption of water is 1,080,000 gal. per mo. The average power used in operating the electric pumps is 230 kw. hr. per mo. at a cost of $8.20, or an average cost of $0.0076 per thousand gallons of water pumped for electricity alone. This compares with an average cost of $47.66 per month or $0.0441 per thousand gallons for water pumped by the gasoline engine in use previous to the installation of electric pumps.

At Lake Mills the equipment consists of a single-acting deep well pump cylinder 5¾ in. dia. by 24 in. stroke which is operated by a pump jack driven by a 7½ hp. 60 cycle, 3 phase, 220 volt motor at a speed of 1,150 r.p.m. The consumption of water is approximately 1,500,000 gallons per mo. The cost of current averages $23 per mo. or $0.0156 per thousand gallons. The average monthly cost of operation and maintenance pumping by gasoline was $67.50 per mo. or $0.045 per thousand gallons. This would indicate that pumping by electricity will show considerable economy over the cost of pumping with the gasoline engine. A large part of the expense of operating a gasoline engine is due to maintenance and where a gaso-

line engine is operated by a station agent or his helpers there is no question of the economy of electric operation over the cost of pumping with gasoline.

Until recent years it was difficult to secure large quantities of water from wells without using an air lift which did not always offer the most economical solution of the problem. The development of the deep well turbine pump seems to have solved this problem to a large extent. The deep well turbine or centrifugal pump is particularly adapted to motor drive and installations of this type have proved very satisfactory.

Operating results covering a period of twelve months on a pump of this type are given herewith: The pump consists of a 15 in. 6 stage, turbine pump driven by a 40 hp. vertical motor, 440 volt, 60 cycle, 3 phase, 1,170 r.p.m. During this period 183,850,000 gal. of water were pumped, using 151,390 kw. hr. at a cost of $3,724 for electricity, an average cost of $0.0246 per kw.hr. or a cost of $0.0202 per thousand gallons of water pumped, the total head being 160 ft.

The efficiency as shown in shop test is perhaps higher than that obtained in field service, although there is no doubt that this type of pump shows very satisfactory efficiency.

While, under suitable conditions, electric drive has proved very satisfactory in railway water service at the same time it would be a mistake to fall into the error of considering it for every installation regardless of its suitability for the conditions of operation as there are many conditions where steam is preferable to electricity on account of the possibility of utilizing the exhaust steam for heating or other purposes as well as for pumping. As stated previously the power cost for pumping with oil engines is almost invariably lower than for electric power. As a result the chief advantage that electricity possesses over an oil engine is the possibility of automatic or remote control with a resultant saving in the salary of attendants. As with other types of pumping installations the maximum reliability is not obtainable through the installation of a single unit and while the construction of duplicate units will, of course, increase the construction cost it is not difficult to justify the additional expenditure on the ground of insurance against interrupted service as well as reducing the maintenance expense due to emergency repairs which are often necessary with a single unit.

The shop test on the above pump showed the following results:

R. P. M.	Total Head	G. P. M.	I. H. P.	H. P. to Pump	W. H. P.	Eff.
1170	13.2	838	40.5	34.2	2.8	8.18
1170	31.9	817	40.6	34.3	6.58	19.2
1170	45.1	802	40.7	34.4	9.12	26.5
1170	59.0	774	40.8	34.5	11.53	33.4
1170	72.3	747	40.9	34.6	13.66	39.4
1170	86.4	725	41.0	34.7	15.8	45.8
1170	99.9	700	41.3	34.9	17.68	50.7
1170	113.0	671	41.7	35.2	19.14	54.3
1170	127.1	637	41.2	34.8	20.45	58.7
1170	140.6	612	41.2	34.8	21.7	62.3
1170	148.6	596	40.9	34.7	22.2	64.0
1170	158.1	567	40.8	34.6	22.65	65.4
1172	169.1	540	40.3	34.1	23.05	67.5
1178	182.0	502	39.6	33.4	23.05	69.0
1180	205.0	437	38.7	32.6	22.5	69.0
1182	223.0	328	35.4	29.6	18.5	69.4
1200	245.0	0	18.8	14.5	0	0

Operation of a Bascule Bridge on the New Haven

Interlocks and Extra Motors Provide for Safety and Surety of Operation. Gas Engine for Auxiliary Power

THE bridge on the New York, New Haven & Hartford which spans the Thames river at New London, Conn., was completed early in 1918 and displaced a double-track draw-bridge which has since been dedicated to the state for public highway purposes. The new bridge is a four-track structure and the lift span is of the Strauss heel trunnion type, consisting of the lift itself, the counterweight truss and box, the counterweight and the operating machinery. The counterweight for operating the lift span is made of concrete, a part of which contains steel punchings.

A waterway 150 ft. in the clear between fenders is provided for navigation. The maximum angle of opening for the lift span is 82.5 deg. with the horizontal.

Operating Equipment

Three-phase, 60 cycle, 2,300-volt power for the operation of the bridge is obtained from the local power plant over a transmission line a little over a mile in length. Three 37½-kva. transformers step this voltage down to 440 for all power purposes and for lighting it is again stepped down to 110 volts.

The motors and reduction gears for raising the lift span shown in Fig. 2 are located in a fireproof house directly over the tracks and back of the span as shown in Fig. 1. Contactors, fuses and resistances, Fig. 3, are placed in a separate room directly below the motors. The controllers and the control board shown in Figs. 4 and 5, respectively, together with machinery for furnishing emergency power, are located in the small white building at the heel of the bascule in Fig. 1.

Four 82-hp., wound-rotor type, 3-phase motors are connected to the gear train. Two of these run idle, being held in reserve for emergency and the other two are used to operate the bridge. The two motors are capable of opening the bridge in 1¾ minutes. Either pair of motors may be selected for use by the large three-pole double throw switch shown in Fig. 5 on the lower panel.

In addition to these motors a 37½-hp. auxiliary motor is provided, which will open the bridge in nine minutes in event of the failure of the large motors. The additional gears through which this motor transmits its power are not in mesh with the main gear train under normal operating conditions. The larges gears of the train, Fig. 2, mesh with two racks mounted on two of the bridge members. A differential divides the power applied to each rack. A 5-hp. motor located in the free end of the bascule is used to lock the span when it is in its fully closed position. Through a

system of gears it is made to extend tongues or steel members between rollers on the adjoining stationary span and thus lock the bridge after the manner that a door is locked. All hoisting motors are equipped with solenoid brakes.

Magnet switches are used for the control of all motors and the lock motor and hoisting motors are mechanically and electrically interlocked with each other and with the railway signal circuits. An air brake is

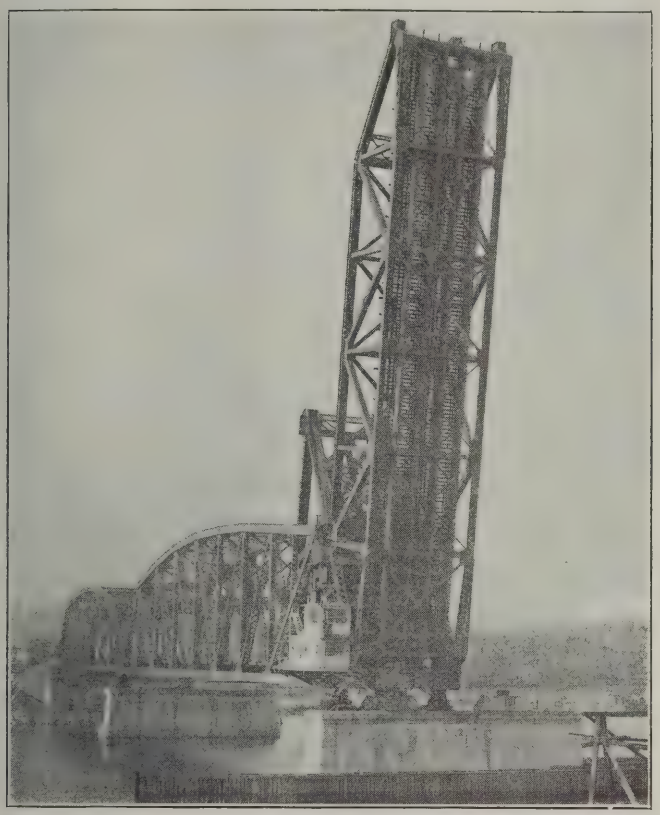


Fig. 1—The Lift Span in the Open Position

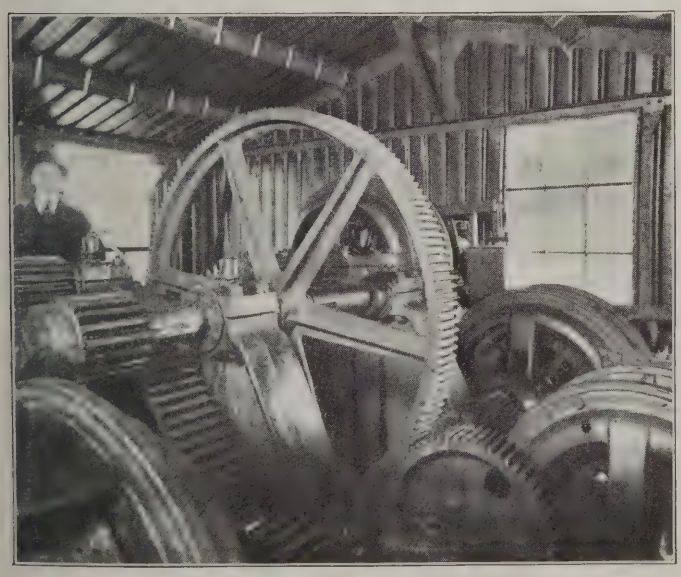


Fig. 2—Interior of Machinery House

supplied for retarding the movement of the bridge or for holding it in any desired position.

As an added precaution in the event of failure of the line current, a gas-engine generator set is provided which supplies current for the 37½-hp. auxiliary motor. This set consists of a six-cylinder, 82-hp. Wisconsin automobile type motor operating at a speed of 1,200 r.p.m., and direct connected to a 37-kva., 440-volt General Electric generator, this power unit being located on the lower floor of the operator's house. The engine is started by means of an electric motor starter controlled by a foot switch in the operator's floor; the spark and gas control as well as the dynamo control being also accessible to the operator. In case of a failure of the service supply of current, the gears can be shifted and the bridge opened and closed with the gas engine generator set and gears re-shifted in 35 min. The average load on the set is 15 kw., but it is capable of delivering 40 kw. A motor-driven air compressor, with a capacity of 25 cu. ft. per min., supplies

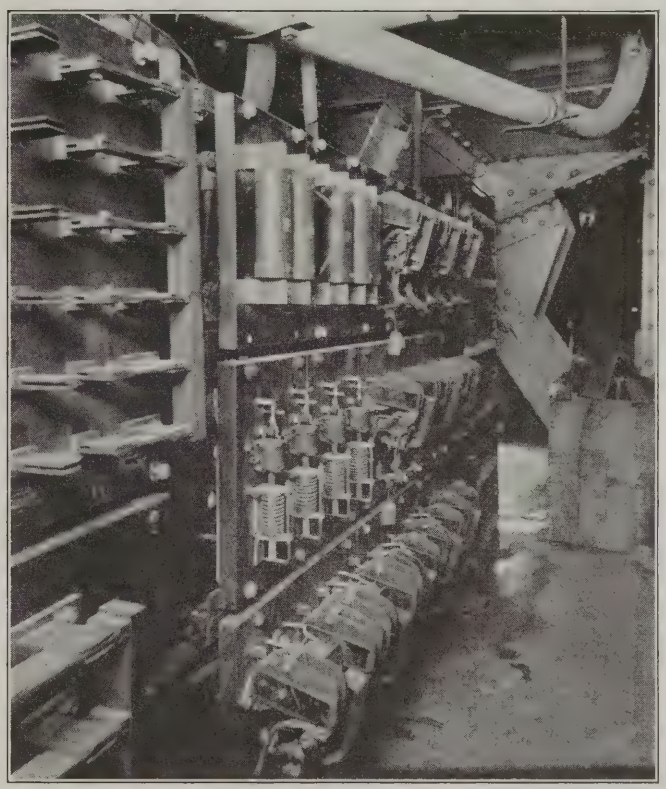


Fig. 3—Main Contactors, Switches and Grid Resistances

air to a 72-cu. ft. air tank at 125-lb. pressure for operating the whistle and strut brakes.

Control

The operator's stand is shown in Fig. 4. Controller No. 1 is used to operate the main hoisting motors and No. 2 controls the locking motor. These two controllers are mechanically and electrically interlocked so that the locking motor can not be operated unless the bridge is fully closed and power can not be applied to the main motors until the bridge is unlocked.

Case No. 5, Fig. 4, contains six pilot lamps which indicate to the operator that the bridge is locked, unlocked, fully closed, one-third open, two-thirds open or fully open.

Cases No. 3 and 4 contain relays which are controlled from a signal tower located at one end of the bridge. The bridge can not be opened unless these

relays are closed by the action of signal tower operator.

If the lift span is moving in either direction and the operator fails to shut off power, it will be shut off

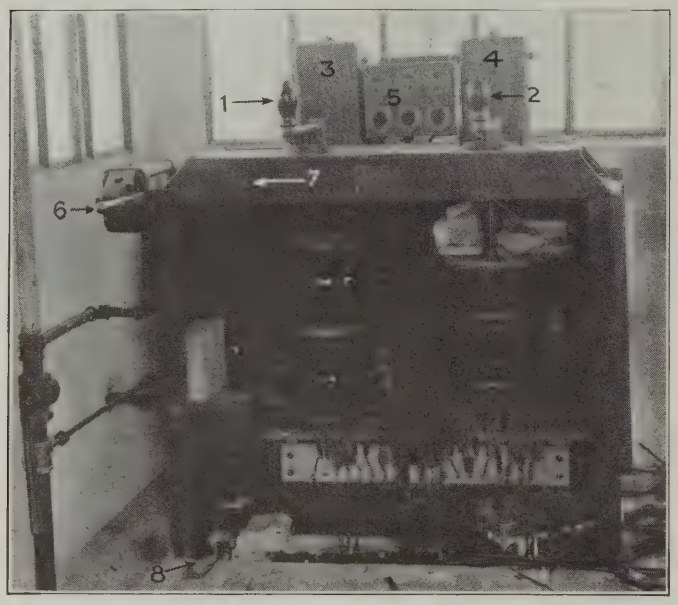


Fig. 4—The Operator's Stand

automatically and the motor brakes set when the span reaches the nearly open or nearly closed position.

The air brake is capable of stopping and holding the span in any position in case of an accident such as

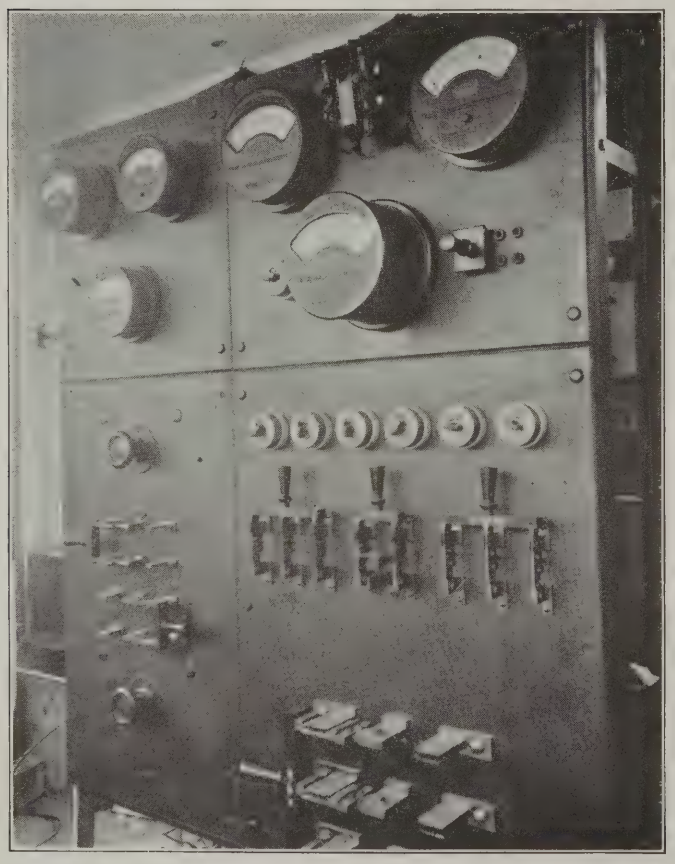


Fig. 5—The Control Board

a broken shaft or gear which would disconnect the span from the operating mechanism and is controlled by valve No. 6.

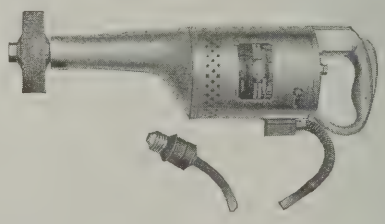
If the bridge is open and the operator is to close it, it is first necesstary to step on treadle No. 8 which closes the contactors to the power supply. The bridge is then brought down by controller No. 1. On the way down the different lights in Case 5 show the position of the span, and when nearly closed a limit switch located in the motor house causes the contactors to fall out and the brakes to be set on the motors. This precaution makes it impossible to close the bridge at full speed. In order to land the bridge it is then necessary for the operator to hold the contactors in with push button No. 7 as well as with treadle No. 8. When the bridge is in the fully closed position as indicated by one of the lights in case No. 5, and controller No. 1 is in the "off" position, the bridge may be locked by the use of controller No. 2. A light shows when the bridge is locked.

The gas engine and the generator which it drives are controlled from the left hand panels of the control board shown in Fig. 5. The right hand panels control the main power circuits. The engine-generator set is in a room directly below the room in which the controllers and control panel are located. In case of failure of the main power supply, the engine is started by an electric starter which receives its power from a storage battery. The starter is operated by a foot treadle located on the floor at the left of the engine control panel.

The spark and gas control may be seen in Fig. 5 mounted on the left of the upper panel. The same controllers are used to operate the emergency motor from the gas engine drive as are used to operate the main motors from the main power supply.

Portable Electric Grinders

The portable electric grinder shown in the illustration is manufactured by the Wodack Electric Corporation, 27 South Jefferson street, Chicago, Ill. The machine is designed primarily to grind down castings too large to be handled at a stationary grinder and is particularly applic-



The Grinder is Fitted With 10 Feet of Extra Heavy Flexible Cord

able for use in the welding shop. It may also be used for buffing and polishing.

The machine complete weighs 13 lb., measures 18 in. over all and the diameter of the motor frame is 4½ in. The 4-inch emery wheel which is supplied with the machine runs at a speed of approximately 5,000 r.p.m. The wheel is driven through chrome nickel steel gears by a completely enclosed motor with self-oiling ball bearings. The motor is of the Universal type and may be used on either alternating or direct current. Pressure on the handle starts the motor and current is shut off instantaneously when the pressure is released.

PRACTICAL STUNTS

A Novel Scheme for Drawing Wire Into Conduit

By E. C. Meilloret

Ever since it has been customary practice to run electrical conductors in conduit, various methods of accomplishing such installation have been devised from time to time. One of the most unique ideas in this line is shown in the illustration. On the Long Island Railroad the car lighting generators are now being placed on the car body and the construction of the cars is such that the only available place for the generator is at the opposite end of the car from that on which it was originally installed. This means that the conduits have

Using a Crane for Drawing Wire Into Conduit

to be extended and rewired, as it does not pay to splice out the old wires. Furthermore, the rewiring does away with the splices in the conduit, which are always objectionable. When installing the new conduit it was found that it was necessary to make several offsets in it, and as the conduit itself is quite long, it required from three to four men to pull these cables through, the cable consisting of two No. 4 and one No. 8 stranded copper conductors. A heavy piece of steel banding wire was used as a snake. One end of this wire was securely fastened to the cable and the other end at the switchboard was wound around the drum of a Franklin shop crane, as may be seen in the illustration. Using the crane in this manner, one man can easily pull the cable in. This scheme has the advantage that the conductors are drawn in with a steady and uniform tension, which makes them less liable to break off at the connection to the snake than when several men pull and tug by jerks. Of course, the method is only applicable when the switchboard locker is located on the platform, and is readily accessible from the exterior of the car.

Drilling Holes Through Glass

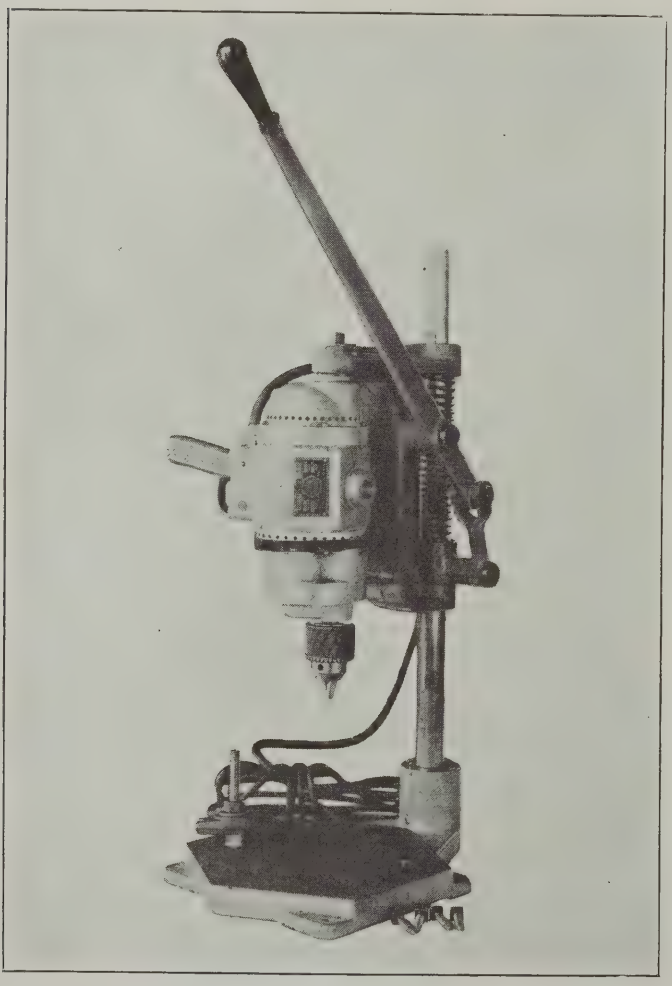
Occasionally, it is desirable to drill holes through plate glass for the passage of high voltage lines or for other purposes. This may be accomplished with hydrofluoric acid but the process is slow, requiring several days to eat through a 3/16-in. glass plate. It is possible to accomplish satisfactory results much more rapidly by following the method outlined. The tools for performing the work consist of a small drill press, a piece of copper tubing, the outside diameter of which corresponds to the diameter of the desired hole, a quantity of powdered carborundum and a little turpentine. The copper tubing must be attached to the spindle of the drill press so that it is held firmly in place. This may be accomplished by heating one end of the tubing, flaring it out and driving it up over the spindle of the drill press. A board 1 in. thick with a hole the diameter of the tube, is rigidly blocked several inches above the glass and serves as a guide for the tubing. A hole in the side of this tubing is necessary to permit the introduction of the powdered carborundum.

Having assembled the material the operation is commenced by putting into the opening on the side of the tubing a small quantity of the powdered carborundum moistened with turpentine. The tube is revolved at about 50 r.p.m. The pressure of the end of this tube against the glass should be slight and the tube should be frequently raised to allow fresh cutting powder to work beneath it. In cutting heavy plate glass by this method it will be necessary to grind off the end of the tube once or twice in order to obtain the full thickness of the tubing at the cutting end. With a small drill press about an hour is required to drill through a 3/16-in. glass plate.

NEW DEVICES

Convenient Type of Bench Drilling Stand

The bench drilling stand, illustrated, has been put on the market by the Black & Decker Manufacturing Company, Baltimore, Md., and is designed to take the 3/8 in., 1/2 in., 9/16 in., 5/8 in., and 7/8 in. portable



Black & Decker Bench Drilling Stand

electric drills made by that company. The bracket carrying the drill can be raised or lowered on the vertical column and is secured in any desired position by means of a split collar and clamping screw. The drill may be swung clear of the base, making it possible to use this stand for such work as drilling holes in the ends of shafts, and other work too high to be drilled on the bench.

Both vertical and horizontal adjustment are secured by means of the clamping screw. An extra long feed lever gives a feed ratio of six to one and 100 lb. pressure applied to the handle will feed the drill under 600 lb. pressure. This facilitates fast work with little effort. In the base of the stand, there are six tapped holes to accommodate 1/2-in. studs used to clamp the work in place. One stud with a nut and clamp is supplied with each stand. The stand is exceptionally rigid in construction, the vertical column being a solid steel shaft 1-7/16 in. in diameter. The base is provided with four holes for fastening the stand to the bench by means of 3/8-in. lag screws.

The distance from the bottom of the base to the top of the vertical column is 30 in., the vertical adjustment of drill being 12 in. The distance from the center of the drill bit to the circumference of the vertical column is 7 in. The vertical travel of drill when operated by the feed lever is 4 in. The net weight is 70 lb. The stand is shipped complete with an adapter block. The sizes and types for which adapter blocks are suitable are stamped on the blocks and only Black & Decker portable electric drills of corresponding sizes and types can be used.

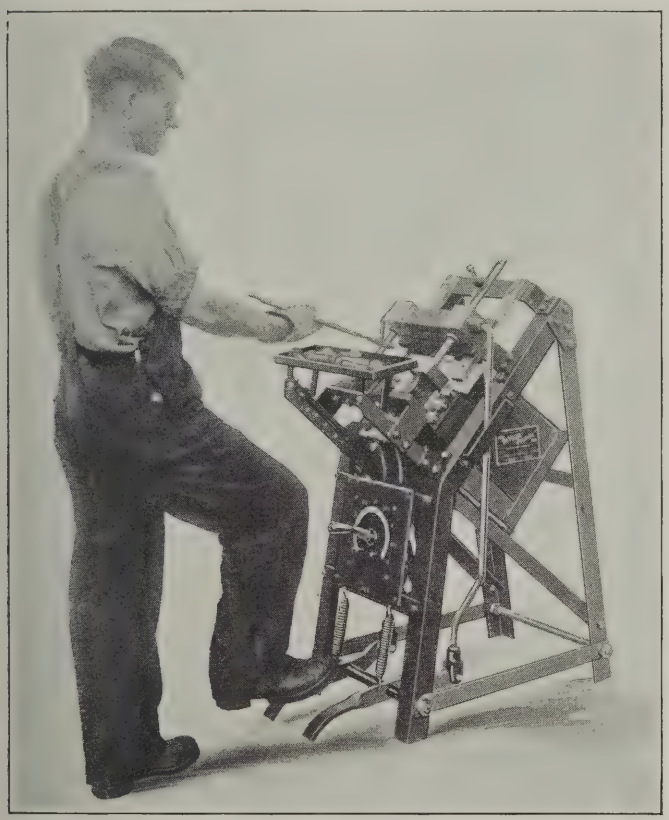
Another Electric Rivet Heater

The machine illustrated in the photograph is one that was recently developed by an Ohio concern to replace the old type forge fire for heating rivets that are used in fabricating steel structures of all kinds. The outfit is portable and can be moved from place to place very readily, only requiring an electrical connection to place it in condition for instant operation.

The heating operator with an outfit of this type does not have to watch more than two rivets at any one time. Since not over thirty seconds is required to heat the average size rivet and the heating operation is under his control at all times, there is no difficulty whatever in maintaining the correct temperature and delivering the rivets in the best possible condition.

The lower terminals of the transformer are stationary, the upper one being moved by means of the foot treadle

which when depressed raises the electrode so that the rivet is released and a cold one put in its place. The speed at which the rivet heats is controlled by means of the regulator located on the face of the outfit just above the foot treadle. The transformer is air cooled so there is no necessity for using water to prevent the terminals becoming heated, which is a very important item in apparatus of this character. Current is consumed at the rate of approximately 18 kw. hrs. per hundred pounds of rivets heated. The amount of current consumed is practically the same on rivets of various sizes, but the



Operator Using the Electric Rivet Heater

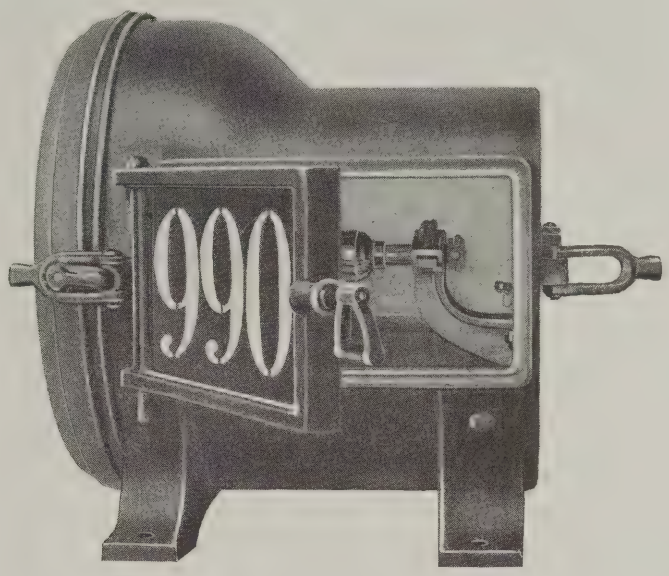
length of time necessary is increased or decreased according to the diameter and length of rivets used.

The top of the outfit being placed on an angle keeps the work in full view of the operator, and a tray for holding rivets is conveniently placed to enable him to handle the work with the least possible effort. Waste is reduced to a minimum by employing angles and plates, and a bail can also be provided to permit of its being moved from place to place with a crane. Construction is rigid and substantial, the upper electrode being the only moving part in the entire outfit. The fact that there is little tendency to wear and nothing to get out of order should insure an exceptionally long-lived piece of equipment.

New Lightweight Headlight Case

The American Metal Products Company, Brooklyn, N. Y., has put on the market under the trade name "Ampro" a new electric headlight cast from a specially strong non-corrosive metal. The headlight weighs complete with mirror glass reflector 45 lb. On account of its light weight one man can install the "Ampro" without the use of tackle or special rigging.

Some of the features claimed for this new lightweight headlight are its weather tight and air tight construction; interchangeable straight and angle side number doors; improved latches which keep doors intact under severe vibration; 14-in. mirror glass reflectors giving

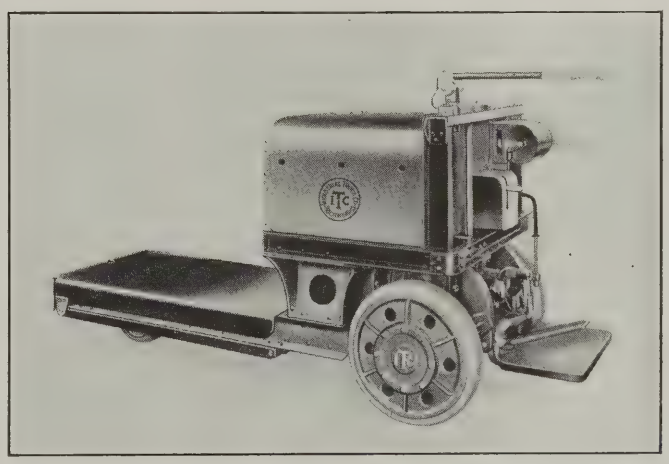


The "Ampro" Light Weight Headlight

maximum illumination required by the Interstate Commerce Commission; a new improved positive focusing device so constructed as to insure against breaking or bending of wires; and a specially designed positive electrical contact block which, when once wired, stays wired.

Self-Loading Type Electric Truck

An industrial self-loading truck of improved design has recently been placed on the market by the Industrial Truck Company, Division of the Cowan Truck Company, Holyoke, Mass. The truck is all-steel and guaranteed for 5,000 lb. capacity. It has an exceptionally quick acting



A 5000-lb. All Steel Self Loading Electric Truck

elevating mechanism and elevates in five seconds when equipped with 28 cells and in six seconds with 21 cells.

The lifting mechanism is operated by an independent, heavy duty, serious wound motor and worm gear reduction. The platform lifts vertically, the rise being 4½ in. The platform may be stopped at any point going up or

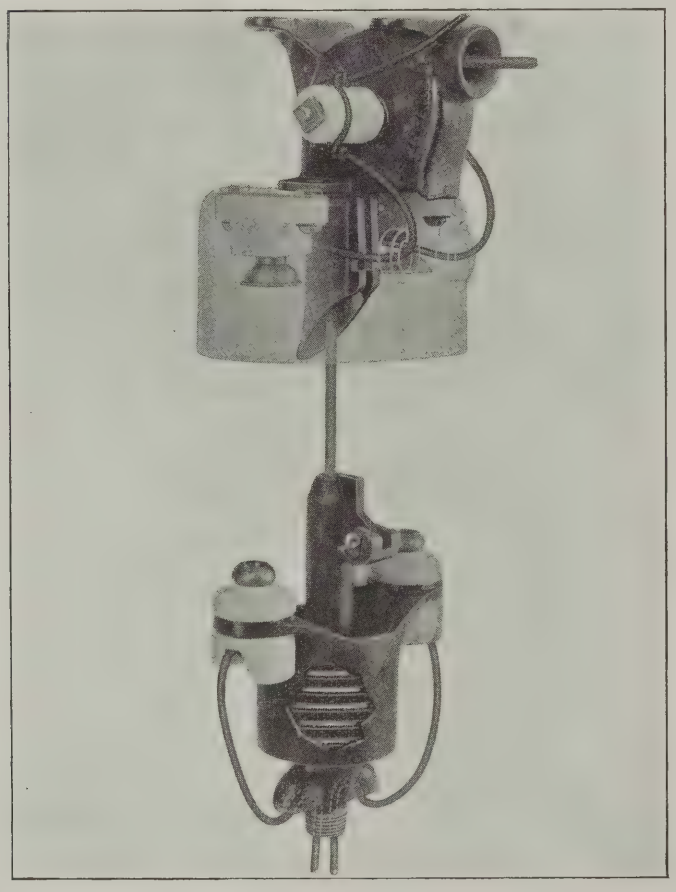
down, and requires only three seconds for full lowering. The rear end is equipped with a heavy bumper which effectually takes all shocks, and protects the lift platform. A drawbar attachment also is provided which enables the truck to be used as a light duty tractor.

An automatic brake and circuit breaker application, four-wheel steer, single reduction worm drive of the power axle and easy accessibility of batteries, lifting, driving and control mechanism are features of the truck. It will operate in intersecting aisles 60 in. wide.

The extreme turning radius, outside point, is 70 ft. 10 in. By folding the foot pedal and steering handle into a vertical position, the overall length is shortened for use on elevators. The length is 102 in. overall or 91½ in. with the step raised. The width is 36 in. overall and the height over the steering shaft head 51 in. Either alkaline or lead batteries are used. The controller is of the drum type with three speeds forward and three reverse.

A New Type of Disconnecting Hanger

The Thompson Electric Company, at Cleveland, Ohio, has recently placed on the market a new type of safety disconnecting hanger, the principal features of which are shown in the diagram and photograph. The main feature of the new underslung model is that the self-acting lock, or dog, is on the part of the hanger which comes down with the lamp. This simplifies inspection and enables the operator to readily overcome any tendency of the parts to stick, due to corrosion or dirt. Even should the lock become corroded (no matter how badly) a pull on the rope will always unlock it, permitting the lamp to be easily removed for cleaning when it comes down to the ground.



Phantom Photograph Showing Arrangement of Hanger Parts

The wing at the top of the latch pin engages the cam portion of the slotted guide and brings the lower contact into alinement with the other contact. The self-acting dog is drawn upward past the notch in the slotted guide as shown in Fig. 2, then as the rope is slowly released the dog drops into the notch, locking the parts together as shown in Fig. 3.

To lower the lamp, a pull on the rope again raises the self-acting dog out of the notch as shown in Fig. 3, then a quick release of the rope causes the dog to slip down past the notch and the lamp is ready to be lowered to the ground. The heavier the lamp, the more firmly the jaw of the dog is forced into the notch in the face of the slotted guide. Another valuable feature of the underslung latching parts is that they may be used in the old model hangers Nos. 30 and 31, manufactured by the company, thus giving those hangers the benefit of the most essential improvement involved in the new underslung hanger.

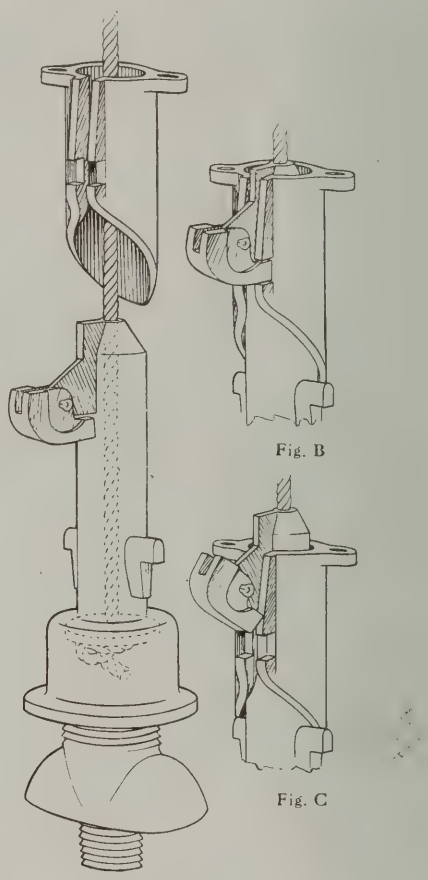


Fig. A

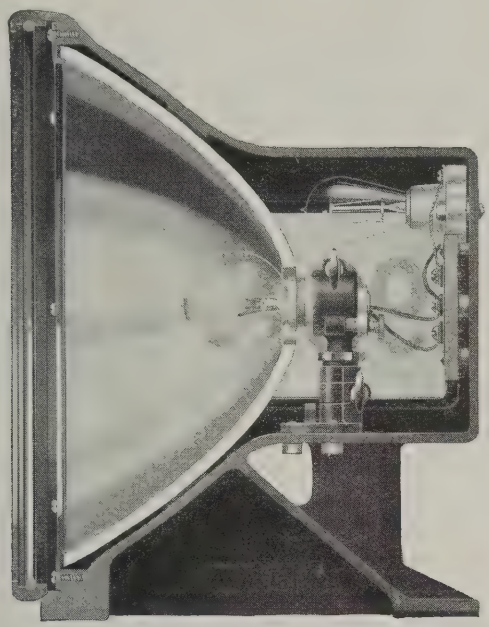
Diagram Showing Successive Steps in Latching Hanger

New Cast Headlight Case

The cast metal headlight case with glass reflector shown in the illustration is manufactured by the Pyle-National Company, Chicago. It is adapted for the use of a 250-watt 32-volt lamp as the light source while the reflector retains the accepted curve and focal length,

thus providing standard intensity and spread of light beam.

The cast case, which is in one piece, is 19½ in. high, 15 in. deep, 20½ in. wide and weighs less than 100 lb. A machined, taper fit is provided between the cast door frame and the body of the case so as to make it smoke-tight, dust and gas-proof. Provision is made for a weather-protected junction between the case and the



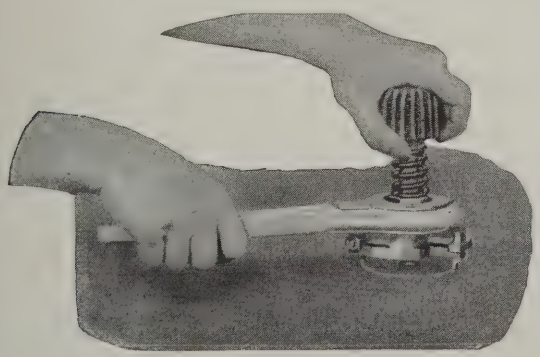
Cross Section of Cast Headlight Case Showing Arrangement of Lamp Equipment

locomotive conduit system, as well as a pre-assembled, electrical distribution within the case.

A 16 in. by 8 in. glass reflector of heavy section is provided and is securely anchored against vibration. The focusing device holds the lamp rigid. The cast case may be furnished without numeral frames, or with side number frames, either straight or angle.

A Ratchet Adjustable Cutter

The "Jiffy" Adjustable Cutter, which is being placed on the market by Paul W. Koch & Co., Chicago, affords a method of cutting round holes through practically any



How the Cutter Is Applied

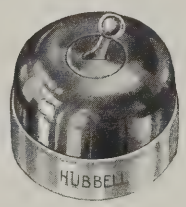
material from paper to steel. The illustration shows how holes are cut through instrument boards, junction boxes, plates, etc. This cutter will cut through both metal and wood with the same set of knives. This tool is designed to cut holes from 1¼ in. to 6½ in. in diameter in wood, sheet metal, cast iron, boilers, tanks, cabinets, steel fibre, slate, asbestos board and many other materials. It is light and portable; it can be tucked away in the tool kit and used out on the job as easily as at the work bench in the shop, and can be used also in any position—on the floor or overhead, in corners or in the open. In fact, its possession will suggest numerous places where it can be used advantageously.

Five New Electrical Specialties

Harvey Hubbell, Inc., Bridgeport, Conn., has recently placed upon the market a number of new electrical specialties shown in the illustrations. The first of these is No. 8171 which is a toggle snap switch. The switch differs from the ordinary snap switch in that it is manipulated by throwing the lever or toggle instead of by turning a key or button. Throwing the lever up makes the circuit; throwing it down breaks the circuit. The movement is positive, quick and snappy.

No. 3916 is a new type of pull socket with luminous acorn which is shown in illustration No. 6725. Any pull socket or pull switch listed in the catalogue No. 16 can be furnished with the luminous acorn as shown in the photograph.

No. 6720 illustrates a 20-ampere composition plug



No. 8171

No. 6720

No. 3916

No. 6725

No. 6712

cap. The body of the plug cap is made of tough black composition with a large milled edge, supplying an extra grip for the fingers. The hole is big enough to admit weatherproof or asbestos covered wire and a generous space is provided for knotting the two cords, thus preventing all strain on the contact screws. It has a capacity of 20 amperes, 250 volts and is ample for all 32-volt farm lighting circuits. The blades are of heavy brass and are set "polarized." They are interchangeable with all Hubbell 20-ampere receptacles, are rugged of construction and will not work loose or bend easily.

No. 6712 illustrates a composition attachment plug with bayonet base.

General News Section

Group Life Insurance for its employees is to be continued by the General Electric Company for another year. During the first year of the insurance plan about $257,500 in death benefits were paid.

Beginning January 1, 1921, the American Metal Products Company, Brooklyn, N. Y., will market its railway electrical specialties consisting of headlights, gage lamps, etc., under the trade name of "Ampro." The Sunbeam Electric Manufacturing Company, Evansville, Ind., has been appointed sales agent for the "Ampro" products.

The Chase-Shawmut Company, Newburyport, Mass., announces the appointment of H. C. Moran, Keystone Building, Pittsburgh, Pa., as district representative for the following territory: Western Pennsylvania, Ohio, Kentucky and West Virginia. The Engineering Equipment Company, 1011 Chestnut St., Philadelphia, Pa., has also been appointed district representative for Eastern Pennsylvania, New Jersey and Maryland.

The Swiss Federal Railways are in urgent need of extending their electrification program promptly, because of the inaccessibility of coal supplies and, according to the New York *Herald,* the Swiss Government is proceeding actively in negotiations with American bankers for a new loan. Provided that there will be no hitch in negotiations, it is expected that a new issue of $50,000,000 to $60,000,000 of Swiss Government bonds will be floated in the New York market during the final week of this month. The last previous issue was floated early in July, 1920, and was for $25,000,000 in 20-year 8 per cent sinking fund gold bonds.

The International Western Electric Company has organized a new company in Argentina, according to a recent announcement made by G. E. Pingree, vice-president of the International company. The new organization will take care of the telephone requirements of the country in the lower part of South America. It will be known as the Compania Western Electric Argentina and will form an important link in the group of subsidiaries which the American company has been establishing during the past few years. H. C. Mitchell, formerly resident manager of the Western Electric Company in South America, has been elected president of the Argentine company with headquarters at Buenos Aires.

Effective January 1, 1921, the general offices of the Stone Franklin Company will be removed from 18 East 41st street, New York, to 6400 Plymouth avenue, St. Louis, Mo., to which point correspondence should be sent. This change brings the company in close cooperation with its manufacturing plant, affording improved service to the railroads. In addition to their general offices in St. Louis, the Stone Franklin Company will also maintain a New York office at 30 Church street, in charge of their president, Ralph G. Coburn, and vice-president, C. E. Walker. H. D. Rohman, at present chief engineer of this company, has been appointed vice-president, with offices at St. Louis, in addition to his present duties. He will have jurisdiction over sales in the west.

A. E. R. A. Will Meet at Chicago

The mid-year meeting and dinner of the American Electric Railway Association is to be held at Chicago on Thursday, February 10. Financing and re-financing of electric railways will be the general subject for discussion at the conference, this problem having been selected as the most important affecting the electric railway industry today. The meeting and dinner will be held at the New Drake Hotel.

Lackawanna Considers Electrification

A recent item in the Scranton *Times* quotes E. M. Rine, vice-president of the Delaware, Lackawanna & Western, as making a statement to the effect that a partial electrification of the Lackawanna is being considered at the present time. Engineers are making a survey of the road in Scranton and vicinity and will doubtless present an estimate as to the cost of placing electric pusher locomotives in service between Scranton and Pocono Summit on the east and Scranton and Clarks Summit on the west. According to Mr. Rine if the electrical engineers can show that the Lackawanna can improve its service and lessen the cost of haulage to the east and west of the city of Scranton pusher electric locomotives will probably be installed. The problem of electrification is being approached wholly from the viewpoint of reducing the haulage expense to the summits east and west of the city. The subject of electric motive power for through trains has not been considered.

Illinois Central Studies Electrification

The Illinois Central has appointed a commission to study electrification of the Chicago terminal facilities of that road and to advise on numerous technical questions involved. This commission will be composed of A. S. Baldwin, vice-president of the Illinois Central, chairman; D. J. Brumley, chief engineer of Chicago terminal improvements of the Illinois Central; Bion J. Arnold, consulting engineer, Chicago; George Gibbs, consulting electrical engineer, New York; Cary T. Hutchinson, consulting engineer, New York, and W. M. Vandersluis, formerly signal engineer of the Illinois Central, who will be engineering secretary of the commission. It is understood that the scope of work of this commission will be to consider and make recommendations on technical electrical problems arising in the electrification of the Illinois Central passenger and

freight terminals in Chicago as outlined in an ordinance of the city of Chicago, passed July 21, 1919. These problems will include consideration of (1) the general trend of development in the various electrical propulsion systems and the probable influence of future development upon installation and operation of lines of the Illinois Central, and (2) the relative advantages of the alternative systems considered in connection with the electrification of (a) suburban service, (b) switching service and through freight service, (c) through passenger service, and (d) interchange with other railroads.

The commission is to begin work immediately, it is understood, with the probability that a report will be made within six months. After the preliminary work is completed it is probable that the commission will be retained as a permanent body to design and superintend the installation of the system adopted. Under the ordinance in which the electrification of the Illinois Central is provided for, the work must begin in 1922. All of the work done by the Illinois Central Railroad in the Chicago terminal area during the last year has been laid out with the future needs of the electrified system in mind. This includes yard layout and the steel cars purchased for present use in suburban service but suitable for later equipment with motors and control.

Present indications are that the suburban service will be handled entirely with multiple-unit cars, and that electric locomotives will come into use only when the electric operation is extended to the through trains.

PERSONALS

Howard H. Marsh, for nearly eight years district manager of the *Railway Age* and the other publications of the Simmons-Boardman Publishing Company at Cleveland, Ohio, has resigned to become president of the Victory Equipment Company, with offices at 444 Maison Blanche Annex, New Orleans, La. As head of the Victory Equipment Company, he will handle the following accounts: McMyler-Interstate Company, Cleveland, locomotive cranes, pile drivers and material handling equipment; Ball Engine Company, Erie, Pa., steam shovels and railroad ditchers; Schaefer Equipment Company, Pittsburgh, Pa., truck lever connections, brake levers, brake rod jaws and stake pockets; and Equipment Manufacturing Company, Cleveland, trucks and trailers.

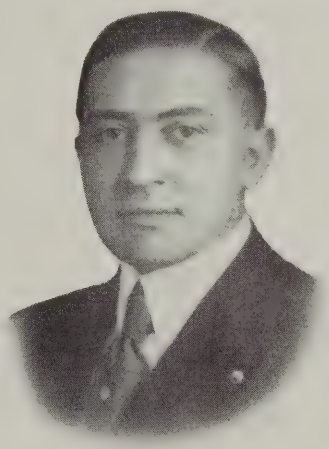
H. H. Marsh

His education, business experience and wide acquaintance fit Mr. Marsh for his new undertaking. He is still a young man, having graduated at the University of Vermont in 1903 with the degree of B.S. in civil engineering. That same year he entered the employ of Engineering News (now Engineering News-Record) as assistant to the western manager, and stayed there until 1907 when he was appointed western representative of Engineering Contracting, with headquarters in Chicago. He left the latter place to go to Cleveland as district manager of the Simmons-Boardman Publishing Company.

Mr. Marsh's removal to New Orleans is due to his desire to be near his family as it was necessary for Mrs. Marsh to take up her residence in the southwest in order that her health might be restored. In addition to his other work, Mr. Marsh will represent the Simmons-Boardman Publishing Company in the southwestern territory.

Paul Lebenbaum has been appointed assistant electrical engineer on the Southern Pacific, with headquarters at San Francisco, Cal., succeeding F. E. Geibel, who has resigned, effective January 1.

Godfrey Gort, general sales manager of the L. S. Brach Manufacturing Company, Newark, N. J., manufacturing of lightning arresters and other signaling specialties, has been elected vice-president and general manager. Mr. Gort began his signal experience on the New York Central as a helper. Next he was on the Interborough Rapid Transit, New York, as assistant maintainer and for two years as signal repairman. He then went to the General Railway Signal Company as assistant wiring foreman on the a. c. installation on the New York Central and then for about a year was signal maintainer on that road. He subsequently served with the contractors who were installing the electric hoisting machinery and lighting and powerhouse equipment on the Pennsylvania terminal and then went to the Hudson & Manhattan. Shortly after this he went to the Union Switch & Signal Company and later was employed by the Norfolk & Western, first as signal wiring foreman and then as assistant superintendent on electrical work. One year later he went to the Illinois Central as construction foreman on the a. c. installation on the Chicago terminal, and in June, 1913, became assistant to J. J. Garth, superintendent of the crossing-gate department of the Buda Company, Chicago. Later in the same year he was appointed construction foreman and sales engineer for the L. S. Brach Supply Company, with headquarters at New York. He remained in that position until 1915, when he was appointed western representative at Chicago and later became the general sales manager at New York of the same company, where he remained until recently elected to the position of vice-president and general manager.



Godfrey Gort

H. F. Brinckerhoff, who has been in charge of the Bluefield and Charleston (W. Va.) offices of the Westinghouse Electric & Manufacturing Company, has been appointed manager of the supply division of the Philadelphia district office of that company.

T. A. Johnson, division electrical foreman on the Illinois Central, with headquarters at Paducah, Ky., has resigned from that position to become assistant electrical engineer on the Central of Georgia with office at Macon, Ga., E. O. King, acting division foreman on the Illinois Central, succeeds Mr. Johnson as division electrical foreman.

OBITUARY

Dr. William Robinson, inventor of the closed track circuit and other valuable devices, died on Sunday, January 2, at the Muncie Sanatorium, in Brooklyn.

Dr. Robinson was born in Cole Island, County Tyrone, Ireland, in 1840. He had lived in Brooklyn since 1844 and was unmarried. Besides being the inventor of the system of closed track circuits for railroads, which the United States Geographical Society classed as one of the epoch-making devices of the century, he also invented an electric spot welding process and the coaster brake on bicycles. In 1878 he organized the Union Electric Signal Company, which he later sold to George Westinghouse and his associates.

He was a fellow member of the American Institute of Electrical Engineers and an honorary member of the Railway Signal Engineers. He had lived in retirement for many years, devoting himself to his inventions.

TRADE PUBLICATIONS

Ward-Leonard Electric Company, Mount Vernon, N. Y., is distributing a small 19-page booklet in which are described the Ward-Leonard Vitrohm dimmers which find extensive use in theatres, lodges and clubs.

The National Metal Molding Company, Pittsburgh, Pa., is distributing a small envelope folder illustrating and describing the properties of "Flexsteel" armored conductors, "Flexsteel" fittings and "Flexsteel" flexible metallic conduit.

The Burton Rogers Company, 775 Boylston street, Boston, Mass., sales department for the Hoyt electrical instruments, has issued a catalogue of Hoyt electrical instruments, including dashboard, miniature switchboard, large switchboard and portable instruments.

The Luminous Specialty Company, Indianapolis, Ind., has recently issued a 20-page pamphlet explaining and illustrating their new lighting fixture "Eye Shield Diffuser." The pamphlet contains many photographic reproductions of this lighting unit as well as numerous instances of its application.

Benjamin Electric Manufacturing Company, Chicago, has recently published a large illustrated 8-page folder entitled "A Big Thought In A Big Way," in which the idea is strongly emphasized of obtaining the proper intensity of illumination in workshops and factories with the idea of promoting efficient production.

Copper-Clad Steel Company, New York, is distributing a small envelope folder which explains briefly the process of manufacture of copper-clad steel conductors. The folder also gives a list of the uses of this conductor, which is marketed under the name of "Copperweld" Wire.

The Cutler-Hammer Company, New York, is distributing a 64-page pamphlet entitled "Dictionary of Uses." The pamphlet explains and illustrates a remarkable number of installations of the C-H electric space heaters. Many of these uses are quite unusual and serve to show the great diversity in the application of this heating unit.

General Electric Company, Schenectady, N. Y., in its bulletin No. 49706 entitled "The Oil Conservator" describes and illustrates a tank equipment to be used in connection with high voltage transformers. The oil conservator eliminates "breathing" and moisture condensation in the main tank, avoids explosions, protects oil from "sludging" and preserves insulation.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., has recently published a 48-page 8½ in. by 11 in. booklet entitled "For the Mine." The new publication illustrates and describes the manual and automatic motor controller, accessory control devices, battery charging equipment for miners' lamps and mine locomotives, electric brakes, solenoids, etc. The booklet is known as publication 836.

The Packard Electric Company, of Warren, Ohio, has issued a bulletin on metering transformers, describing the weatherproof and switchboard types of single, two and three-phase potential and current transformers. The weatherproof, or outdoor type, of oil insulated transformer has been developed to meet a demand for transformers which shall avoid the building of a housing to protect them from the weather.

Tubular Steel Poles.—Bulletin No. 14-C of the National Tube Company, Pittsburgh, Pa., is an attractive 48-page booklet which sets forth the advantages of tubular steel poles. The application of this type of support to high automatic or manual signals, trolley wires, telegraph and telephone lines, transmission lines and lighting fixtures, is illustrated and described. A tabulation of sizes, weights, etc., facilitates the selection of the pole best suited for the particular service. The closing pages of the bulletin are devoted to tables, giving the properties of steel pipe.

The Okonite Company, New York, has recently issued a cloth-bound volume containing 104 pages, 6 in. by 9 in., which is devoted to the illustration and description of the many products which this company manufactures. Approximately every type of wire and cable manufactured by the Okonite Company is illustrated and described in this book. Numerous tables are also given which include complete information concerning the physical and electrical properties of the various conductors listed. A large number of photographs are also included showing the different processes of manufacture of the Okonite products. On the inside of the back cover an electric wire computer is attached for determining the size of wire to be used in electrical construction. Accompanying the hand book is a small envelope folder entitled "Spliced for Life" in which the properties of Okonite and Manson tapes are presented.

Railway Electrical Engineer

Volume 12 FEBRUARY, 1921 Number 2

Throughout the industrial world today an attempt is being made to apply more scientific measures to studying the capabilities and personalities of men to decide just where they can be fitted into an organization to the best advantage. The railroads generally have given too little attention to how best to select men in the first place, and then to their training them after they have been taken into the service.

Blazing a Trail

The electrical department on the railroads has developed and grown at a tremendous pace in recent years. This rate of growth will continue because electrical apparatus generally is distinguished by its ability to increase capacity and efficiency compared with other forms of energy. The application and maintenance of electrically-operated apparatus require a high degree of skill and intelligence and if the best results are to be obtained, critical and careful attention must be given to the selection and training of employees in the electrical department. That this has not received greater attention in the past is doubtless due to the fact that the department has been small and in a state of development. It is time now, however, that the problem be tackled vigorously.

It will be just as well in studying the situation to look entirely outside the railroad field and into the industries —particularly those in the electrical field—for suggestions as to how to go about the matter. Unfortunately the railroad mechanical departments, with which the electrical departments are in most intimate touch, except in a few places, have thus far failed to grasp the importance of going into these matters in a big way. The electrical department may even yet blaze a trail for them to follow.

The railroads are up against a mighty serious proposition. Under the record-breaking business last fall they failed as a whole to earn within 33 per cent of what Congress intended they should, as expressed in the terms of the Transportation Act. Business has fallen off greatly and many roads are now operating at a loss. The shipping public will not stand for a further increase in rates.

Will You Do Your Part?

There remains only one other way out of the difficulty. Operating expenses must be reduced—indeed they must be very greatly reduced. This will require the hearty and intelligent co-operation of every employee from the call boy, office boy and apprentice up to the president and the chairman of the board. There are many places in which savings may be made, but the actual extent to which they can be made will be measured by the proportion of the employees who really use their brains and put forth their very best efforts. Millions of dollars, for instance, are wasted every year in loss and damage to freight, caused by carelessness and pure thoughtlessness on the part of employees—and the term employee, by the way, includes everybody on the payroll and is not here used in any restricted sense. Past experience has conclusively demonstrated that this loss can be reduced to a comparatively low figure by real team work and intelligent application throughout the organization.

In the same way savings may be made in time, energy, and material throughout the entire railroad organization. Unfortunately it is ordinarily mighty difficult, if not impossible, to get the employees generally to realize this. Now, however, the situation is so serious that there is some hope of awakening them. If these savings are not made, only one other alternative remains—to cut salaries and wages. Possibly this may be necessary in any event, but the possibility and extent of it will be reduced in the exact proportion to which a real effort is now made to get the best returns from every dollar expended.

Electrical welding may be considered as preferred work as the operators receive a higher standard rate of pay than machinists in the same railroad shop. This is entirely in keeping with the kind of work they do, since autogenous welding requires special knowledge and special skill. There are two factors however, which operate to make this higher rate of pay undesirable. The first is that it is a flat wage rate, and the second is that it is always desirable to get a job done as quickly as possible. These two conditions operate against good results as the quality of the weld is of the greatest importance and should be put ahead of everything else.

Paying the Welding Operator

Because of the higher basic rate of pay and because he is privileged to do so, a machinist may decide to give up his lathe and take up electric welding, in spite of the fact that he has had no experience in this kind of work and has not the inherent qualities that are necessary to make him a first-class welding operator. The result is that a lot of time is lost in training and much material is wasted. Speed means a lot of work done in a little time, but it should never be sought after if it means a reduction in quality of work done. The operator must be conscientious as well as skillful, he must have careful training and it is essential that all his work be checked up to

prevent the possibility of his becoming lax. Too often a welder's work begins to fail after he has decided for himself that he has become a first-class welder.

A good supervisor can almost always tell the difference between a good and a bad weld and the way the jobs hold up, together with tests he may be able to make from time to time, give him an excellent check on the kind of work that is being done by any certain operator. Payment for welding should be in proportion to the ability of the operator and the quality of the work he turns out. There is a good reason for the higher rate of pay for welders and it can hardly be considered a bonus, but if a bonus were given for the quality of work turned out, it would undoubtedly help to improve the results now obtained. Many welders outside of railroads are already being paid on a basis of quality and it is quite possible that this basis will eventually be adopted by the railroads.

Is One Kind of Power Practicable?

Having different kinds of power for the electric operation of trains makes it necessary to have a greater number of different types of electric locomotives; it would seem desirable to have only one kind of power so that all electric locomotives could be operated over the electrified sections of any other railroad. This matter of standardization has been carried much farther in England than it has in the United States and it is interesting to note the result. During the latter part of 1920 the Advisory Committee on Electrification of Railways recommended the adoption for English railways of direct current at voltages of 750, 1,500, or multiples of these values, with either overhead or third rail collection for future installations and recommended continuing the use of existing 600-volt and 1,200-volt direct current systems. The committee also recommended that the London, Brighton & South Coast Railway be permitted the use of single-phase current.

A recent issue of London Engineering commented on this decision as follows:

"Considering the constitution of the committee and the fact that in this country direct current has always been favored, the decision to adopt a 1,500-volt direct-current system is not surprising. As regards a real standardization, however, the report leaves us very much where we were before. In adopting a voltage little used in this country hitherto, and in leaving the existing electrified lines untouched, the committee has obviously adopted a policy which is of little assistance to real standardization. In view of the fact that a considerable amount of electrification work has already been carried out, and that it is very doubtful indeed that any particular system can be the most suitable system for the electrification of all railways, standardization at this period is liable to prove undesirable. Efforts to standardize railway electrification do not, on the whole, appear to have met with much success either here or abroad."

Selecting a standard system for English railways is a simpler problem than selecting one for use here in America, as the problems involved do not include such widely different forms of railroading and the distances are not so great. If the question is to be disputed in England, American railroads can hardly be expected to adopt a standard in the near future. Standards are desirable, but overstandardization may under some circumstances be worse than none at all. An authority on the use of direct-current said recently, "If you want to be sure of results use direct current, and if you have got time, consider alternating current." Both alternating and direct current have proved their worth and have great possibilities, and each problem of electrification must be worked out for both systems as a separate problem involving the amount and kind of traffic to be moved over a certain profile.

Studying the Electric Headlight

The general adoption of electric headlights has been accomplished with a remarkably small amount of serious trouble. It is remarkable because of the fact that there are so many different types of headlights in use. The manufacturers of the several equipments have produced the machines which in their respective opinions most successfully meet the requirements. It may be that some of these machines are stronger in some respects than others; some are better suited to certain operating conditions than others, and it is altogether probable that some of the equipments have inherent weaknesses which must be given careful consideration from the standpoint of maintaining the equipment As time goes on and more experience is gained in the operation of these electric headlights, it is almost certain that there will be refinements and improvements in the design of almost every one of the types.

In order that data be available from which the designers may be guided in improving these machines, the various railroad companies should take steps to investigate the operation of turbo-generator sets and make suitable arrangements for testing them thoroughly. The article which appears on page 80 of this issue entitled "Temperature Rise in Headlight Generators" gives an excellent example of one type of test which may be performed on headlight equipment. The data obtained from this test appear to be quite conclusive, for it would be practically impossible to study the charts which accompany this article and not be thoroughly convinced that excessive brush pressure is something to be carefully avoided.

A great many tests have been made with regard to the illuminating properties of the light unit, but the studies which have been made of turbo-generator sets themselves are rather few. The investigation of the turbo-generator operation is one of the most fertile fields to which the electrical engineer may profitably devote himself.

New Books

The Engineering Index for 1919. *Published by the American Society of Mechanical Engineers, 29 West 39th street, New York. 527 pages, 6 in. by 9 in., bound in cloth.*

The purpose of the Engineering Index is to provide a convenient and satisfactory guide to engineering literature. The 1919 edition of this index is the most complete and comprehensive work of its kind ever published. It contains over 12,000 references to articles published during the year 1919 in nearly 700 engineering and allied technical publications. The compilation of this index is based upon a review of approximately 1,100 periodicals, reports, and other publications by the engineering staff of the American Society of Mechanical Engineers. These publications are printed in ten different languages and comprise what is probably the most complete collection of scientific and engineering publications in the world. All of the publications referred to in this index are now a part of the Engineering Societies Library in New York.

Typical Bitter Root Country Through Which the St. Paul Is Now Electrified

Electric Motive Power in Freight Train Service*

One C. M. & St. P. Locomotive Handles 2,800 Ton Trains on 0.7 to 1 Per Cent Ascending Grades

By W. S. H. Hamilton
Railway Equipment Department, General Electric Company

HEAVY tonnage freight trains are not only the most numerous on mountain railroads, but are also the most important and difficult from a train handling point of view. Previous to the electrification of the Chicago, Milwaukee & St. Paul, there were no roads electrified in this country where heavy trains of ordinary merchandise were handled on mountain grades. (The Great Northern electrification at Cascade Tunnel and that of the Baltimore & Ohio at Baltimore are not considered because steam engines are used to assist in starting.) Roads carrying ore or coal entirely have an immense advantage in that the cars are nearly always uniform and usually are all-steel equipment which can withstand rough treatment without injury. On the Chicago, Milwaukee & St. Paul the cars are of all kinds and descriptions, and in rush seasons are often loaded beyond their normal capacity. While an effort is made to keep the weakest cars at the rear of the train, still there are many cars in service which were not designed to transmit the drawbar pull required in modern heavy freight service.

The majority of freight trains do not run on a schedule. True, there is a schedule, but it is mostly used for convenience in dispatching and trains are not expected to adhere to it closely. To handle freight most effectively, the locomotives should be able to get the trains over the division in about eight hours and yet be able to handle the maximum tonnage possible. To do this they should be able to take advantage of the profile and speed up wherever possible, consistent with safety. On mountain grades it is most economical to use helpers, and this usually allows the same train weight to be handled over the entire division.

On mountain grades ascending, the maximum speed permitted by the desirable power input to one train with two locomotives will usually be 15-20 m.p.h. (16 m.p.h. on Chicago, Milwaukee & St. Paul). When operating on lighter grades, ascending, the locomotive should be able to go faster. The maximum safe speed is probably about 25-30 m.p.h., but again, this speed may be limited by the desirable power input to a single train. The maximum safe speed on the level or "water" grades is somewhere between 35 and 45 m.p.h., but this varies considerably, depending upon the track.

In descending mountain grades the maximum safe speed is about 15-20 m.p.h. and on the lighter grades 25-30 m.p.h.

The Chicago, Milwaukee & St. Paul freight locomotives are of the geared motor type, shown in one of the illustrations. The full load speed is 16 m.p.h. at 3,000 volts and the maximum operating speed for the gear ratio is 30 m.p.h. The control provides three running speeds, two full field and one shunted. These are shown on the chart, together with the speed curves on accelerating resistances. Two regenerating connections are provided, one giving a speed range from about 17-30 m.p.h. and the other about 9-15 m.p.h. The first (parallel) speed is the one generally used. Motor driven exciters are used to obtain the necessary field excitation during regeneration.

Freight Train Handling

The couplers of a freight car are not rigidly fastened to it, but are connected through a friction or spring arrangement or both, which means there is considerable

*This is the second of a series of three articles on this subject. The first dealt with passenger service requirements and passenger train operation and the third will deal with the use of helpers in freight service. The author acted as an instructor to engineers on the locomotives used on the Chicago, Milwaukee & St. Paul from December, 1915, to August, 1917, and from December, 1919, to April, 1920.

stretch in them when transmitting a large drawbar pull. This is called "slack," and for practical purposes is taken as 1 foot per car. If an 80-car train is started with all the slack "bunched" at the start, the locomotive will move 80 ft. before the caboose starts. Those who have ridden freight trains much can best testify to the shock produced if any attempt is made to speed up the locomotive until after the caboose has been started. This "slack" represents the most difficult problem in freight train handling and the first, last and most important rule in freight train handling is to *"properly control the slack."*

Starting a Train on an Ascending Grade Without a Helper

Let us consider as the first problem in heavy freight train handling, starting a train on an ascending grade of not over .7 per cent with a single locomotive. On such a grade the train will not start back down the grade by simply releasing the brakes. On the Chicago, Milwaukee & St. Paul one locomotive handles a maximum train of 2,800 tons, about 60 cars, on grades of .7 to 1 per cent. On the Missoula division, between St. Regis and Deer Lodge, a maximum train of 110 cars, or nearly 5,500 tons, has been handled by one locomotive against a maximum grade of .4 per cent. The first start at a terminal is made after the brakes on the train have been tested. Usually, when coupling onto the train, it is pulled out as much as possible before testing the brakes in order to see if it is all coupled and also to detect any short air hoses. These frequently give trouble because of excessive slack in the drawbars and at times a short extension coupler has to be put between cars in the hose line.

When ready to start, the locomotive is backed against the train enough to bunch the head third of the train and is then started ahead. In starting extreme care must be taken not to get the head portion of the train moving too fast before starting the rear portion, as this is liable to set up shocks severe enough to pull out a drawbar. Since the drawbar pull required to start a car from rest is much more than that required to keep it just barely moving, a long freight train has almost to be started car by car and the problem is to keep the locomotive just barely moving until the entire train has been started. If the locomotive is allowed to "stall" while doing this, it is usually necessary to start over again.

The engineer, therefore, in starting brings the controller to the first notch and off again once or twice before leaving it there. (This does not mean that the first notch on these locomotives gives too much tractive effort, as it provides only enough to just about move the locomotive alone, but if the controller were left in that notch in the beginning the locomotive would speed up too much and pull the slack out of the head cars too quickly.) As the locomotive moves, car after car is started and the engineer watches the ground carefully and also the ammeter, and when the locomotive seems to be on the point of stalling, brings the controller out another notch. Considerable experience is required to be able to judge just the proper instant, as for best results the controller must be moved just as the locomotive seems to be stalling without actually allowing it to do so. As soon as the locomotive has traveled a distance equal to the amount of slack in the train, the acceleration may be increased to any desired amount which is usually as near the wheel slipping point as it is desirable to go. This varies according to rail and weather conditions.

In first starting a freight train, especially in cold weather, it is necessary to run it slowly for the first three or four miles out of the terminal in order to warm up the journal boxes gradually. If this is not done hot boxes will result. This is accomplished by accelerating to the series running position of the controller and allowing the locomotive to run there for several miles before going on into the parallel positions. This same precaution must be taken after a train has been standing for some time in cold weather.

In making an ordinary stop where there is no necessity for stopping very quickly, the controller is eased off a

C. M. & St. P. Freight Locomotive with a 100-Car, 5,000-Ton Train, Eastbound at Thelma on the Missoula Division

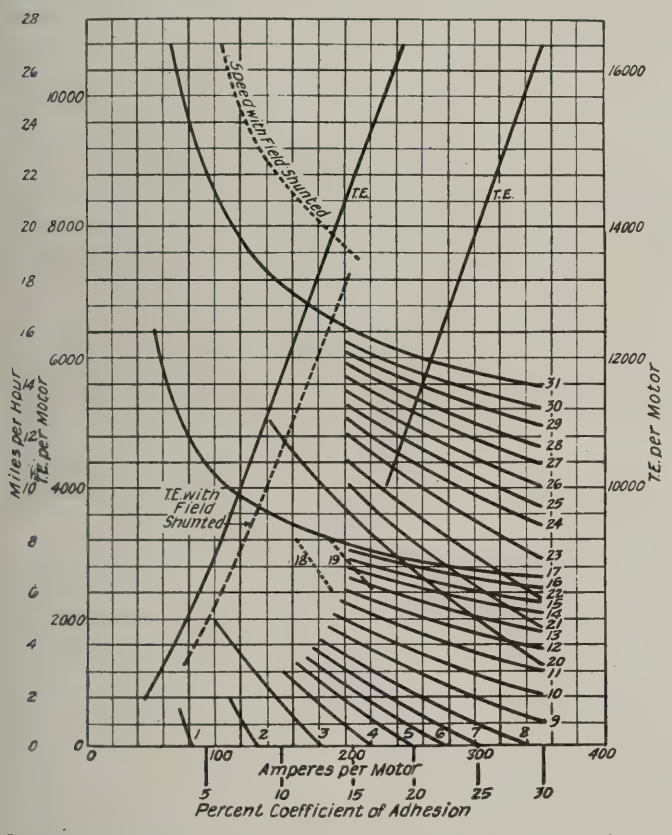
notch or two at a time until the first and second notch is reached, where it is left until the train stops. The independent brakes are then applied on the locomotive and the controller is shut off. This stops the train without shock and without any interchange of slack. In starting again, it is usually necessary to take slack, but quite often an attempt is made to start without taking the slack; while this may be successful, it requires a higher value of current. If there are any weak cars ("soft shells") near the head end of the train, this practice should be avoided.

In starting or stopping on an ascending mountain grade with only one locomotive, about the same procedure is followed as on the lighter grade, with the exception that it is very difficult to take any slack without excessive shock to the train. However, in such cases the trains are not very long and can usually be started without taking the slack. In one case that the writer is familiar with it was necessary to set a few hand brakes at the rear of the train in order to be able to take enough slack and release them by whistle signal after the locomotive had the train started again.

Comparison of Steam and Electric Operation

Before considering operation down grade, a comparison may be made between steam and electric locomotives as regards their ability to start a heavy train. The electric locomotive is superior because in the first place the torque on a steam engine is not constant, but varies,

depending on the position of the cranks. In the second place, it is difficult to judge exactly the drawbar pull being developed by a steam engine during the time that the slack is being taken in the train and after the train has just started. Undoubtedly an experienced engineer can tell from the sound of the exhaust how much drawbar pull is being developed by the engine after it is in motion, even at fairly slow speeds, nearly as well as can be told by the ammeter indications on an electric locomotive. During the times referred to, however, the exhausts are so few and far between that they cannot be used as a guide. The effect of the expansion of the steam in the cylinders is variable and difficult to judge while moving very slowly. This point is brought out clearly in wrecking operations, where it is desired often times to move a locomotive only a few inches at a time. In



Speed-Tractive Effort Curves on Resistance for C. M. & St. P. Freight Locomotives

such cases it was found to be much easier to do this with an electric locomotive than with a steam engine. The ammeter indication on the electric locomotives is at all times a measure of the drawbar pull being developed and the engineer can tell just how close the locomotive is to the wheel slipping point and thereby judge whether to move the controller another notch or not.

After the train is in motion there is practically no difference between the steam and electric locomotives until speeds of 6-8 m.p.h. for Mallets and 10-12 m.p.h. for simple engines are reached. Here the steam engine begins to lose torque in gaining speed, while on the other hand the torque of the electric locomotive can be held at full value until speeds beyond 16 m.p.h. are reached. This results in considerable saving in time in starting a train.

Before taking up down-grade operation with electric locomotives, it is well to consider this operation with steam engines and air brakes. When a train arrives at the top of a mountain grade it is stopped and a test of the air brakes is made by applying the brakes and noting that they apply properly on all cars, or at least noting that the gage in the caboose shows a reduction. After this the brakemen go over the train and turn up the retainers on all cars. A retainer is simply a small valve connected in the exhaust pipe from the triple valve. It is usually mounted near the hand brake staff in an accessible location and has a small handle which controls a cutout cock inside. When this handle is pointing down ("turned down") the cutout cock connects the exhaust pipe from the triple valve directly to atmosphere so that when the brake pipe is recharged after an application of the brakes, the air from the brake cylinder can exhaust through the triple valve and the retainer to atmosphere and release the brakes on the car. This is the position the retainer is kept in ordinarily. When this handle is rotated upward 90° or "turned up," then the cutout cock closes the passage to atmosphere and compels the air to pass through a check valve so designed that it will open only with pressures in excess of 15 lb. With this condition, when the brake pipe is recharged after an application of the brakes, the air from the brake cylinder will exhaust through the triple valve and retainer until the brake cylinder pressure is reduced to 15 lb., when the retaining valve closes and holds this pressure in the brake cylinder. Of course, this leaks off after a time, but ordinarily it may be relied on for 7 to 15 minutes after the retaining valve has closed. This means that the brakes do not entirely release when the brake pipe is recharged and prevents the train speeding up too much between successive applications of the brakes. It is this feature which makes mountain grade railroading possible with automatic air brakes on heavy freight trains.

The train is then started, and as soon as the speed reaches, say, 6-8 m.p.h., a fairly heavy application of the brakes is made. This applies the brakes on all cars. This is held for a few seconds and then the brake pipe is recharged. The next and succeeding applications are lighter (about 10 lb. reductions in the brake pipe pressure), being only sufficient to move the triple valves and insure a fresh supply of air each time to the reservoirs on the cars. The cycle of operations between successive applications requires about 1 minute and is divided about as follows: Full release 20 seconds, running position 10 seconds, application 20 seconds, lap 10 seconds. Of course, these times are only approximate and are varied by the engineer, depending on how the train is holding and the speed. The train crew, in the meantime, are watching the cars carefully and the retainers are "turned down" for a few minutes at a time on any cars which show signs of wheels overheating. Stops are made as required to cool the wheels. The brakes on the locomotive driving wheels are kept off during the descent to keep from overheating the tires.

When making a stop, a full service application of the brakes is made, the engine driver brakes are allowed to apply, and just before the train comes to rest an additional application is made, which is quite necessary. When the first application is made preparatory to stopping and is held on, leakage in the brake pipe throughout the train gradually causes the brakes to apply hardest

at the rear of the train, and this part of the train has a tendency to stop first and stretch the train out. By making an application just before the train stops, it has the greatest effect on the head end and stops that part first, or at least at the same time as the rear end. Failure to make this final application often causes trains to break-in-two.

When the train is stopped, the brake pipe is recharged and the independent brakes are applied on the engine to hold the train. As the brakes on the different cars leak off the train gradually bunches against the head end and the locomotive, but since this does not occur on all cars at the same time, the cars with the brakes set retard this bunching and thus prevent excessive shocks in the train. This is another very desirable feature secured by the use of retainers and will be referred to again.

With the electric locomotives regeneration is used to control the speed and braking effort on descending mountain grades. On the freight locomotives used by the Chicago, Milwaukee & St. Paul, the controller is so arranged that it is necessary to bring the main handle to either the full series or full parallel running position before the braking handle can be moved to the positions to apply and regulate the amount of regeneration. This makes the application of regeneration when "tipping over" the summit of a grade very easy, as the controller can simply be left on and the braking controller brought on as the speed increases. The regeneration starts gradually and the train bunches as each car in turn passes over the summit. However, when starting on a down-grade the application is not so easy, because of the motoring pulling out the train slack before regeneration is applied.

The trains stop for an air brake test at the summit; this is done by making a 10-lb. reduction in the brake pipe pressure at the locomotive and noting whether this shows on the gage in the caboose. The conductor then makes a 10-lb. reduction by means of the valve in the caboose and the engineer sees it by means of the brake pipe gage in the locomotive. It is the usual practice to turn up retainers on 25 to 30 per cent of the cars, all at the head end of the train. These assist in controlling the slack in case a stop is made on the grade, as previously described.

Starting a Train on a Descending Grade

The train is then started, and if it is not all on the down-grade the regeneration is applied as described above. This same method is used on all grades of 1 per cent or less. If, however, the start is made from rest on a grade of 1.5 per cent, or over, then the train is started and allowed to run, checking it a little at first by means of the independent brakes on the locomotive. This bunches most of the slack gradually. When a speed of about 17-19 m.p.h. is reached, a light application (about 8-10 lb. reduction) of the automatic brakes is made, the independent brakes on the locomotive being allowed to apply. When this application becomes effective, the main handle is brought out quickly to the parallel running position and the braking controller is brought on several notches. The independent brakes are released as soon as regeneration commences and the automatic brakes as soon as it has built up to the proper value. This procedure keeps the train bunched while regeneration is being applied and the cars with retainers assist in this, but they soon leak off and do not assist in holding the train after a few minutes.

Frequently one of these locomotives has to take a greater tonnage down a grade than it can hold by regeneration alone. To do this the air brakes have to be used to help hold the train. This condition occurs most often on the 2 per cent grade between Donald and Piedmont. One locomotive can hold back about 2,200 tons, whereas the tonnage down this grade is usually 2,800-3,000 tons. Under these circumstances more retainers are turned up, though never on more than on 40-50 per cent of the cars (all at the head end), and after regeneration has commenced additional applications of the air brakes are made from time to time to control the speed, the driver brakes on the locomotive being kept released. These applications are all light (10 lb. or less), being just enough to work the triple valves on the cars and most of the work is done by the brakes on the cars with retainers up. These, however, do not heat up their wheels enough to bother. This method is entirely successful in operation, but is greatly facilitated by the arrangement provided on the bipolar passenger locomotives, whereby the brakes on the locomotive are automatically kept released while the locomotive is regenerating.

In stopping the train, the regeneration is reduced by moving the brake handle back a couple of notches and a light service application of the brakes is made, the driver brakes being allowed to apply. When the speed has decreased enough so that regeneration has practically ceased, both handles are shut off, and such additional applications of the brakes are made as are necessary to stop the train.

A Correction

The wheel arrangement of the St. Paul passenger locomotives manufactured by the General Electric Company was given as 2-4-8-8-4-2 in the January issue of the *Railway Electrical Engineer,* table I, page 12. This is an error and should have been given as 6-8-8-6. The guiding axle at either end of the locomotive with two driving axles form a six wheel truck.

Photo from Keystone View Co.

King Constantine Leaving Lucerne, Switzerland

Looking Down One of the Transverse Trucking Bridges Which Connect the Truck Platform

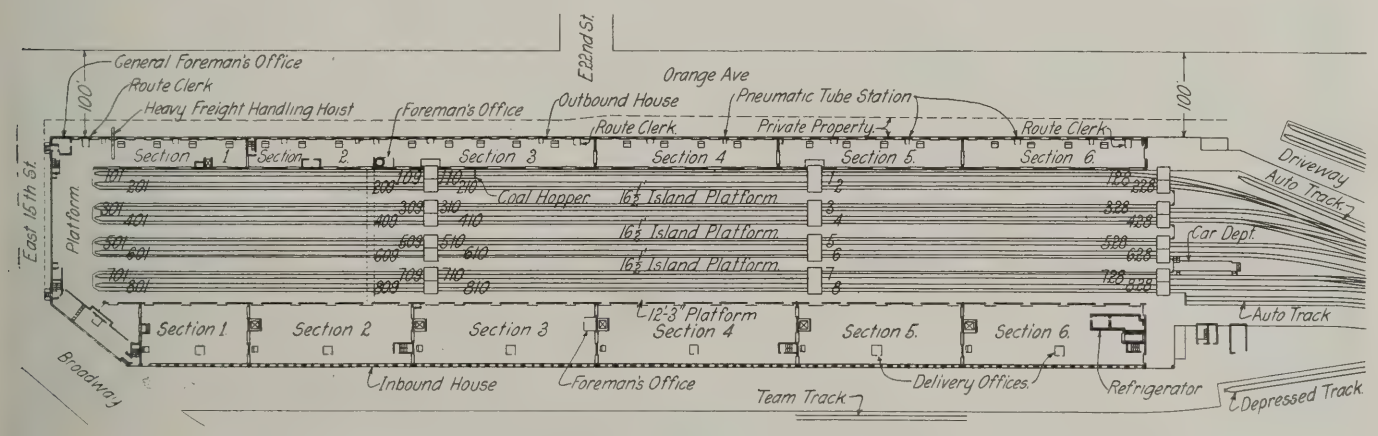
Operating a Modern Freight House Efficiently

Practices Adopted at New Orange Avenue Freight House of New York Central at Cleveland

By W. E. Phelps
Assistant Engineer, New York Central, Cleveland, Ohio

IN March, 1918, the New York Central completed at Cleveland, Ohio, its large Orange Avenue freight terminal, which had been several years in building and on which several millions had been expended to produce a plant combining the greatest convenience to the public, exceptionally efficient operating conditions, and an unusual regard for the comfort of its employees. When the new terminal was opened, three outbound and three inbound l.c.l. stations, and one team yard, were closed, and all the business was consolidated at the new location. The stations abandoned were largely outgrown and poorly located, 50 or 60 ft. below the level of the business and manufacturing district which they served, while the new plant is less than a mile from the center of the business district and on a level with it.

The terminal as a whole, comprises a 3½-mile branch from the New York Central's Cleveland belt line and includes, besides the double-track connecting line, a 1,000-car storage and classification yard and the 35-acre terminal yard proper containing the team yards, which will have about 550 cars capacity when fully developed, and the freight house and its appurtenant platforms and house tracks occupying about 10 acres.



Floor Plan of the Freight House in Relation to the Track Layout

House and Track Arrangement

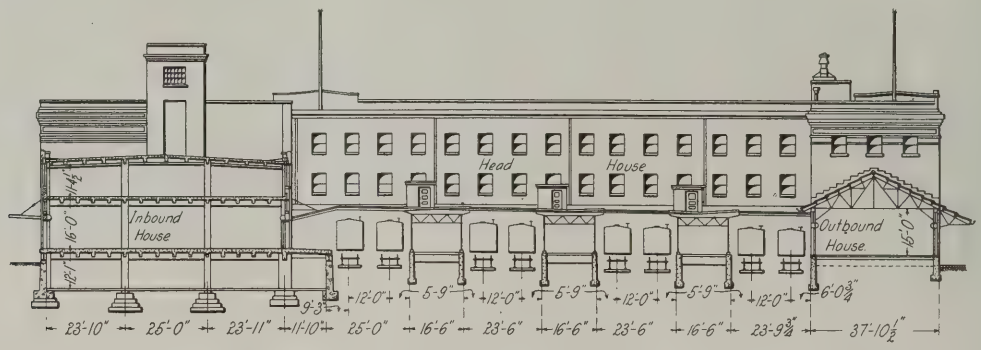
The team tracks range in length from 10 to 30 cars, with driveways 40 ft. or 37 ft. wide, the narrower dimension having been finally determined on as standard. They are largely paved with good second-hand paving stone (on a 6-in. concrete base) removed from the many streets

which were vacated or changed to permit construction of the plant.

The 38-ft. outbound house and the 75-ft. inbound house are each 1,262 ft. long and stand opposite each other, 156 ft. apart, with the space between them occupied by a 12-ft. 3-in. platform along the inbound house, and four pairs of tracks separated by three 16-ft. 6-in. roofed-over island platforms. There is no platform along the outbound house, the track-side doors of which are 19 ft. wide and 42 ft. apart, center to center. The two houses and the platforms are connected across the west end by a basement-and-three-story headhouse. The main floor of this comprises a platform 50 ft. wide, while the upper two stories, which extend also around over 296 ft. of the outbound house, contain the house offices, record room, employees' cafeteria, recreation rooms, etc.

For operating purposes, the houses and platforms are also connected laterally at the east end and at two intermediate points by three sets of wooden bascule-lift bridges 16 ft. wide, which are raised and lowered by hand. Signal lights, suspended from the roof above the bridges, automatically indicate to trainmen whether they are up or down: continuous-burning red light signals are also shown over the bumping posts at the ends of the eight house tracks.

The house tracks are of 28 cars capacity, and are divided into three sections of 9, 10 and 9 cars each by the bridges, so that the eight tracks have a total capacity of 224 cars. With the tracks cut into these short sections, the bridges provide easy access to each platform at intervals, and with a platform (or house door) adjoining each car, door-to-door spotting of cars is entirely unnecessary. The designated number of cars for each track is simply set in and cut for the bridges. As a result of this and the modified "permanent set up" of outbound cars, described later, the house is pulled and set up with unusual rapidity.



Cross-Section Through the Freight House Layout, Looking Toward the Head House

"Spot" Numbering System

Freight is handled between cars and trucks all on one floor, the tracks and the streets surrounding the houses being on the same level. The inbound house has full length basement and second floors, reached by seven large elevators; dirty and rough freight, like oil and barrels, baled rags, etc., is placed in the basement, and furniture on the second floor, but most of the freight is handled on the first floor; fundamentally this is a "one-level" station, as distinguished from some stations recently built in which tracks and driveways are on different floor levels. In the outbound house there are 55 driveway

Interior of the Inbound House Showing the Use of the Lift Truck Trays

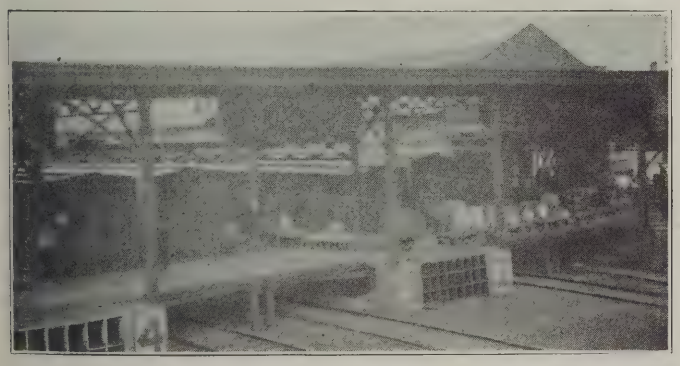
doors, with an automatic five-ton dial scale located between each pair of doors, while the inbound house has 110 driveway doors, with six scales.

The "spot" numbering system for cars at the house gives the westerly car on each track the number 01, and running from that up to 28 for the easterly car, while each position number is prefixed by the track number, as 101 to 128 for the cars on Track No. 1, 201 to 228 on Track 2, etc. Thus the same position numbers are directly opposite on all tracks, and the system is easily assimi-

Outbound Train Handling Special Equipment Used for Hauling Awkward Pieces of Freight

lated by the men. Prominent signboards permanently posted on the platforms opposite each car space indicate the numbers.

The equipment used for hauling the freight between houses and cars comprises about 600 four-wheel trailers with 18-in. main wheels, about 40 low-down all-steel trailers for handling barrels, etc., and a number of new-type dollies. The standard type trailers have 3-ft. by 6-ft. platforms, rigid hook couplers, and are equipped with removable pipe or T-iron gates. The earlier types of these trailers were of the usual wooden construction, but 175 recently purchased and put into use are of all-metal construction (except floor), with Hyatt roller bearings, and



Typical Trailer Train—Outbound House, Showing Covered Trucking Bridges

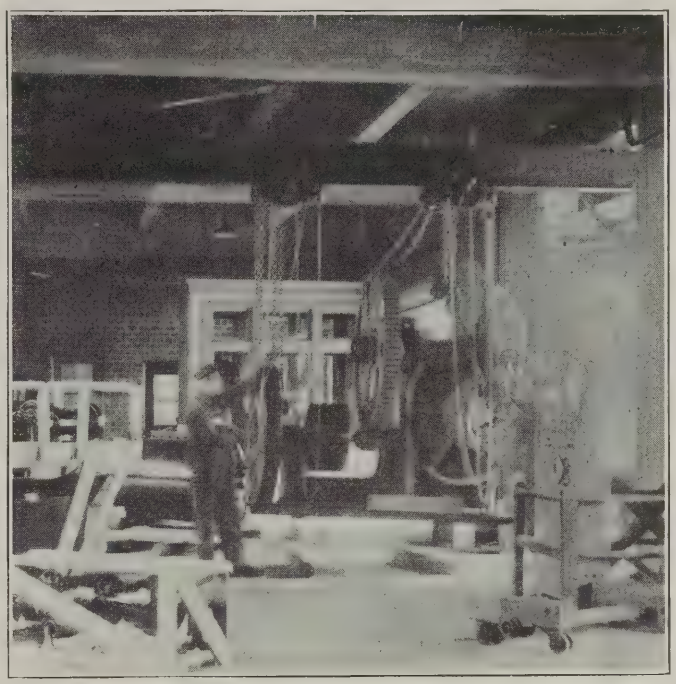
possess the unusual feature of spring suspension for all four wheels, primarily a floor-saving measure, as well as a spring drawbar device.

Among the dollies are two special types of Stuebing trucks: one a six-ton capacity dolly 9-in. high, with large wheel faces, spring suspension and roller bearings, with a bed of rollers set into the frame, for handling heavy machinery by rolling on or off: the other a cradle caster type for handling the many shipments of long shafting or forgings with special reference to easy handling into the car

Eight Mercury tractors, seven small three-wheelers with 30-cell Edison batteries and developing a 600-lb. drawbar pull, and one larger one for handling heavy machines, etc., are the motive power for hauling this freight and equipment. Their batteries are charged at night and given a heavy boost at noon. Trains vary as to the number of trailers, and range as high as 18, the average being about 10. In both houses the crews consist of the motorman and a trainman, the latter's duties being to couple and uncouple trailers, watch his train to prevent freight from falling, etc.

A Separate Organization for Each House

The house organization, under a general foreman reporting to the agent, consists of two entirely separate units, one for each house and each under a foreman. There are many differences in the handling of the two



Receiving Heavy Machinery with the Help of an I-Beam Runway at the Door

kinds of freight and some unusual methods are used in each house, so they will be described separately.

A driver with freight for outbound shipment goes first to any one of three route clerks with his bills: these clerks, in conveniently located special booths in the house, have all the requisites, including experience, for properly routing freight. They mark one copy of the bills with the spot number of the car into which the freight is to go, and return it to the driver, together with a ticket showing the number of bills, time of arrival at the house, etc.; the driver then goes to the indicated door and the checker, after transferring the freight onto trailers, chalks it with the spot number shown on the bills, and his symbol letter, and "OK's" the ticket which enables the driver to secure his receipted freight bills from the route clerk. This ticket is also marked to show the time of surrender, thus giving a record of the elapsed time at the station. The checker also marks on the ticket the time he started and finished handling the load.

The average loading per trailer at this house is about 1,330 lb., an exceptionally high figure which is accounted

for by many metal products, including auto springs, hardware, bolts, nails, wire, rods, bars and plate, and quantities of paints and oils, manufactured in Cleveland. Outbound heavy steel products, machine tools, etc., are transferred from trucks by a freight hoist consisting of an I-beam runway extending 9 ft. out over the driveway, and 26 ft. back into the house, on which are two four-ton, geared trolley hoists, which can be worked separately or together, and easily handle the heaviest loads acceptable at the house, onto whatever equipment is needed for moving them to the cars.

The loaded trailers in each section are lined up in train order and pulled by tractors onto the proper platform, the rear trailers being cut off one by one as they pass the proper cars. After all the loads have been cut off, the tractor gathers a train of empties which have been partially assembled by the stowers to take back into the house. No trailers have freight for more than one car—there is no "peddling." As soon as the freight has been pulled off the floor, the checker "shoots" his bills to the office by means of a pneumatic tube system, for rating, billing, etc.

On the platforms, a head stower in charge of an entire

Typical Trailer Movement in the Outbound House

platform, shifts his men from point to point as necessary to prevent congestion at any one place, and supervises the loading generally.

To minimize the back-hauling of freight which is taken out on a platform, marked for a car which is found to be full when the freight reaches it, about a dozen telephones connected with the house exchange have been placed on the platforms, enabling a stower to notify the foreman promptly when a car is filled, and a special system of "despatchers'" phones to each route clerk's and checker's booth allows the foreman to notify these men quickly of this condition. A bulletin board on which each route clerk's, checker's and stower's loading errors are charged up to the individual develops considerable rivalry among them.

A flexible "permanent set-up" is used for outbound cars, which are arranged in "groups," a group being a number of cars going to one principal station for unloading or further distribution. Each group is permanently assigned to one position on the house tracks, but the assignment of cars within the group is elastic, within the foreman's discretion. This elasticity obviates the necessity of switching set-backs onto precise spot locations and also permits making extra cars without disarrangement of the set-up, at the same time giving nearly all the advantages of a strictly permanent "set-up." Cars are all set at night. The first train of outbound house freight leaves the yard about 45 min. after the house closes, and the second train soon after.

Handling Inbound Freight

In the handling of inbound freight the methods are somewhat analogous, but differ materially in detail. Each firm regularly receiving sizable quantities of freight is assigned a certain space in the house for its freight, the space being marked by suspended signboards, but two of the six sections are assigned to smaller and less regular consignees whose freight is sorted and piled alphabetically according to initial. Thus each consignee's freight

Some of the New Equipment

is always all together and is always found at the same place in the house, which is a great advantage in reducing confusion.

Tallymen at the cars load all freight on trailers to the different sections, loading them to capacity with any number of lots of freight. They are then hauled by tractor to the indicated section, and the piler in the section distributes it as necessary. When the lots are large enough

Loading a Four-Ton Casting on An All-Steel Roller Top Dolly Truck

to justify it, and the size and shape permit, the freight is piled directly from the trailers onto 3½-ft. by 5-ft. lift truck platforms awaiting delivery. About 400 of these platforms are in use, equipped wtih stake pockets for use when necessary. One Stuebing 5,000-lb. (hand) lift truck in each section is used to move these loaded platforms to the door for delivery, one man doing it quickly in one easy operation. These platforms and trucks not only speed up delivery and save labor, but are conducive to cleaner and closer piling, and thus save room, this being a valuable feature; it is rather startling to consider that in ordinary freight house operation, according to figures from many houses, the floor space occupied by a ton of freight awaiting delivery, figured at fair rental rates, costs close to 20 cents.

A large refrigerator room is maintained for the storage of perishables awaiting delivery or shipment, and facilities are provided for icing a small number of dairy cars. Two tracks are regularly assigned for inbound freight and are set at night and as often during the day as necessary. A comparatively small amount of transfer work is done in connection with the inbound freight work.

The yards are piped for air, and light repairs are made and air brakes are tested and cleaned as the cars stand at the house for loading or unloading. A car repair shop is also maintained at the classification yard.

Fire drills, with adequate apparatus, are had frequently, and considerable attention is given to fire prevention work. All employees are provided with individual steel lockers and a high class cafeteria and a recreation room are maintained in the office portion of the building, while the house men have a comfortable basement dining room and lounging room, the only place in the house where smoking is permitted.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

VII.—Lighting Circuits, Distribution Panels, Fixtures, Lamps, Fans and Switches

LIGHTING circuits are of vast importance with every type of car lighting equipment, and should they fail it is necessary to install emergency candle lamps until repairs can be made. These candle lamps are very undesirable, because they give poor illumination and fill the car with smoke. Considering their importance, car lighting circuits should be designed with an aim for mechanical strength as well as electrical efficiency.

Fig. 1 shows a distribution panel for passenger car lighting. This is one of a variety of panels for car lighting service and is equipped with switches and fuses for four individual lighting circuits. The lighting circuits are carried overhead in conduits, either under or over the roof. Fig. 2 shows a conduit diagram of a day coach. In this case the conduit is run over the roof with a junction box opposite each lighting fixture.

Car Lighting Fixtures

Car lighting fixtures are of special construction to meet the exacting conditions of railway service. They are designed to some extent artistically, but more stress has been laid on the mechanical and illuminating features. The variety of fixtures in use today for car lighting service is amazing. In looking over a catalog on electric car lighting fixtures, one may find illustrated a variety of over two hundred fixtures, all of which are in use on the various railroads today.

There is also a variety of reflectors and glassware in combination with the various lighting fixtures. The car lighting engineers have been giving specialized study to the science of illumination, consequently the manufacturers of glassware have produced a great variety of shapes, colors and compositions in lighting glassware.

When electric car lighting was introduced the cars were made of different material and of different design than those of today. The fixtures were more ornamental than serviceable. When the steel car arrived the car lighting engineers realized the importance of units that would not

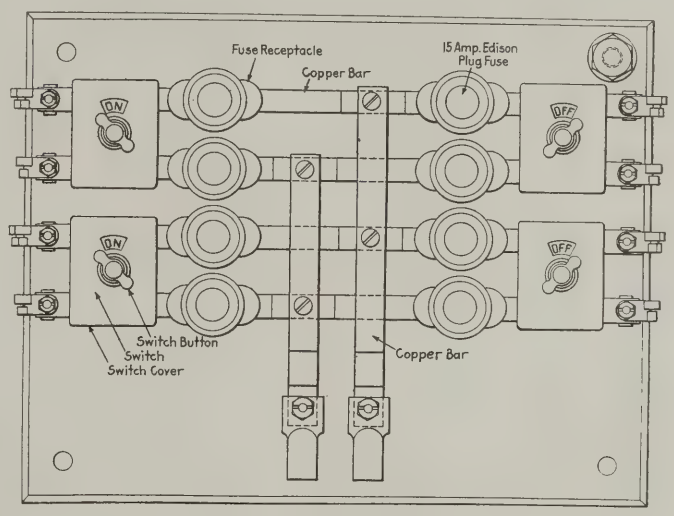


Fig. 1—Crouse-Hinds Control Panel for Passenger Cars

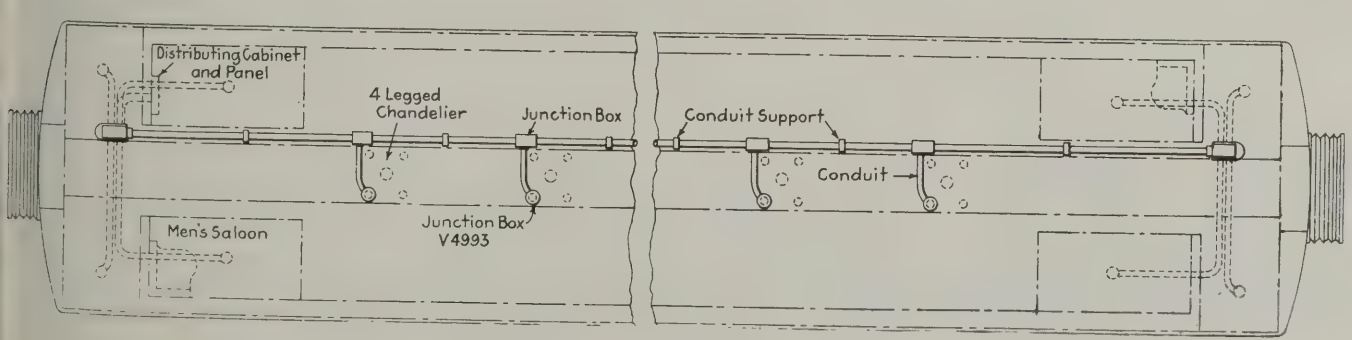
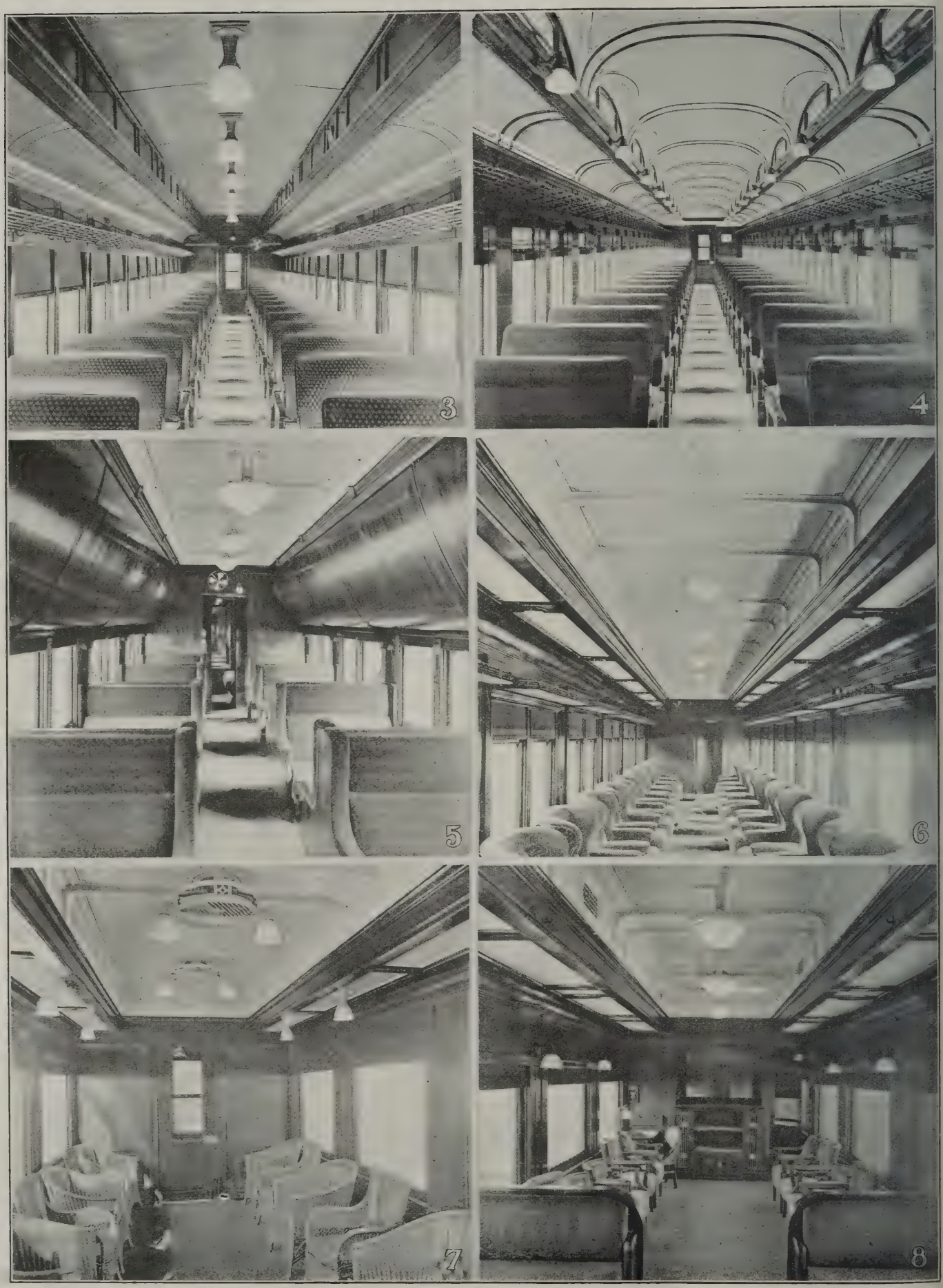


Fig. 2—Conduit Diagram, Conduit Over Roof for Lighting Circuits



Figs. 3 to 8—Interiors of Different Cars Showing Various Types of Fixtures and Their Arrangement

only generate light efficiently but give efficient illumination also. One has only to compare the old with the new to appreciate the great progress that has been made in car illumination.

There are many different types of cars on the railroad.

Fig. 9—Arrangement of Fixtures in Dining Car

Dining car, mail car, baggage car, horse car, refrigerator car, parlor car, sleeping car, etc., are some of these. The type and location of the lighting fixtures depend

Fig. 10—Various Fixtures for Postal and Mail Storage Cars

upon the type of car, as a fixture or reflector suitable for one class of car would not do for another. There are, however, three general systems of car lighting in use.

1. Center deck fixtures mounted down center line of the car.
2. Large number of small fixtures mounted on the half deck.
3. Combination of center and deck fixtures.

Day Coach Lighting.—Single unit fixtures with the open reflectors are in general use in day coaches. The lamps are either hung from the ceiling in a single row down the center line of the car, as shown in Fig. 3, or in two rows on the deck, as shown in Fig. 4. The single

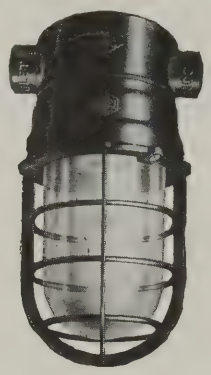


Fig. 11—Type of Lamp Used in Refrigerator Cars

row in the center has the advantage over the double row in the deck, in that it does not require as many lighting units and gives better illumination for passengers to read.

Pullman Car Lighting.—The illumination of Pullman cars requires more study than that of the day coach because the appearance of the fixture from an artistic standpoint is a big factor. For this reason the indirect, semi-indirect and luminous fixtures, as well as the open reflector type, are in use. The illustrations give a little idea of the methods of lighting Pullman cars, but is far short of a complete outline. The fixtures in sleeping

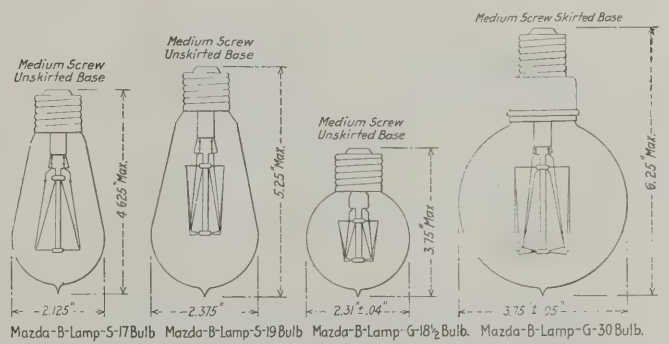


Fig. 12—Mazda "B" Train Lighting Lamps (Bulb Classification)

cars are placed in a single row down the center line of the car, as shown in Fig. 5. Each berth is illuminated by two small reading lamps. Sleeping cars are also equipped with aisle night lights which are used to illuminate the aisle when the center lights are switched off. They are located under the seat ends.

Pullman parlor and club cars are illuminated on the same principle as the sleeping car, with the exception that they have small lamps along the deck over the chairs instead of the berth lamps. See Figs. 6, 7 and 8.

The fixtures in dining cars are usually located in a single row down the center line of the car with the addi-

tion of small bracket lamps on the side walls over the table, as shown in Fig. 9.

Postal cars are equipped with fixtures in a single row down the center line of the car and over the letter cases. The post office department specifications call for a certain amount of light at the various stations throughout the car, therefore the efficiency of the lighting units must be maintained to comply with these specifications. Fig. 10 shows a variety of units for postal and mail storage cars.

The private and business cars are illuminated along

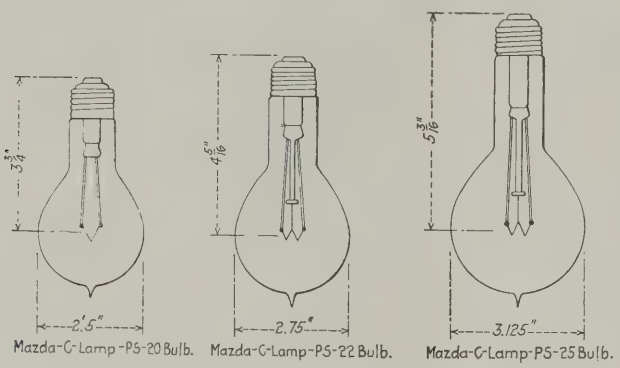


Fig. 13—Mazda "C" Train Lighting Lamps (Bulb Classification)

the lines of the various Pullman cars, but the fixtures are designed with an aim for a pleasing appearance more than illuminating efficiency.

Refrigerator car lighting requires fixtures and switches of a very different design from those used in passenger coaches. For example, Fig. 11 shows a vapor proof fixture that is used for lighting the refrigerators in this particular type of car. These cars are designed with a large refrigerator at each end of the car, the doors of which open into a small compartment located at the center of the car. The refrigerator lights are controlled

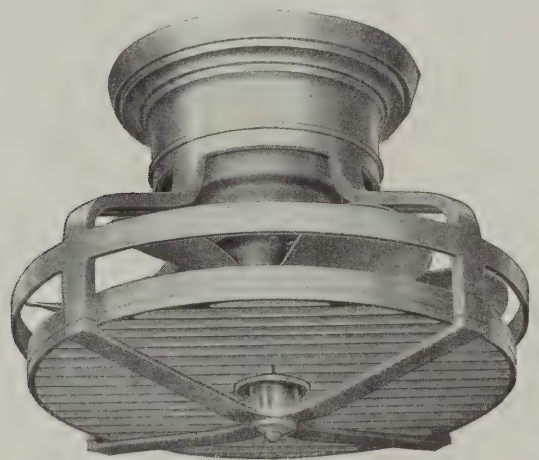


Fig. 14—Safety Ceiling Fan

automatically by a push switch operated by a strike which is attached to the refrigerator door.

Train Lighting Lamps

Train lighting lamps are subjected to violent vibration and therefore require more rugged construction than incandescent lamps used for other purposes. There are two types of train lighting lamps in use today, the mazda B train lighting lamp and the mazda C train lighting lamp.

The mazda B lamp is a vacuum type lamp with a tungsten filament, and is used in various sizes and shapes. Referring to the table and to Fig. 12 it will be noted that the mazda B lamps are used in sizes ranging from 10 to 50 watts and with four different sized and shaped bulbs. It will also be noted that the 50-watt mazda B lamp generates approximately 500 lumens of light or 10 lumens per watt of power consumed.

The mazda C lamp is a gas filled lamp and is also used in various sizes and shapes. The train lighting lamp table shows that these lamps are used in sizes ranging from 50 to 100 watts and with three different sized bulbs, as shown in Fig. 13.

The mazda C lamp has an advantage over the mazda B lamp, having a higher efficiency. In other words, the mazda C lamp gives more light per watt of power consumed than the mazda B lamp. For example, we stated above that the 50-watt mazda B lamp generated approximately 10 lumens per watt of power consumed. By referring to the train lighting lamp table it will be seen that a 50-watt mazda C lamp generates 739 lumens of light,

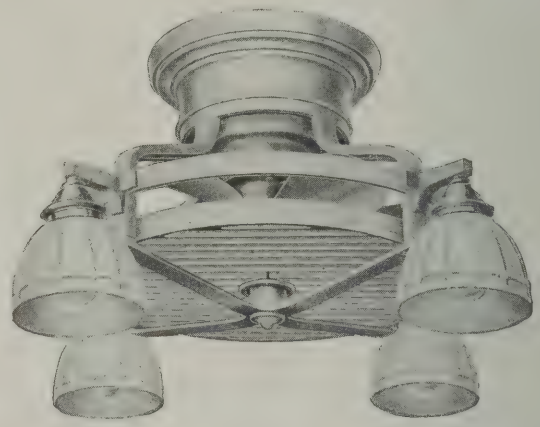


Fig. 15—Safety Ceiling Fan With Lamps Attached

or approximately 15 lumens per watt of power consumed, which is, indeed, an improved efficiency.

Classification of Bulbs.—The numbers and letters that are used to designate the various shaped bulbs may appear confusing at first sight, but a little study of Figs. 12 and 13 will illustrate the following: The round bulbs are marked with the letter *G*, meaning globular. The straight side bulbs are marked with the letter *S*, meaning straight side. The pear shaped bulbs are marked with the letters *PS*, meaning pear shaped.

The numbers designate the extreme diameter of the bulb, expressed in ⅛" units as follows:

S-17 bulb is 17 x ⅛", or 2.125"
S-19 bulb is 19 x ⅛", or 2.375"
G-18½ bulb is 18½ x ⅛", or 2.31"
G-30 bulb is 30 x ⅛", or 3.75"
P-20 bulb is 20 x ⅛", or 2.5"
P-22 bulb is 22 x ⅛", or 2.75"
PS-25 bulb is 25 x ⅛", or 3.125"

TABLE OF TRAIN-LIGHTING LAMPS

Standard Schedule

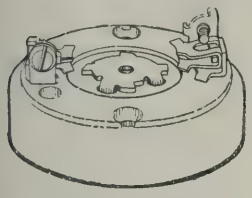
Watts	Volts	Lamp	Bulb	Lumens	Lumens per watt
10	30–34	madza "B"	S–17	94	9.4
10	30–34	mazda "B"	G–18½	87	8.7
15	30–34	mazda "B"	S–17	144	9.6
15	30–34	mazda "B"	G–18½	137	9.14
25	30–34	mazda "B"	S–17	244	9.76
25	30–34	mazda "B"	G–18½	231	9.24
50	30–34	mazda "B"	S–19	506	10.1
50	30–34	mazda "B"	G–30	515	10.3
50	30–34	mazda "C"	PS–20	739	14.78
75	30–34	mazda "C"	PS–22	1,210	16.12

Intermediate Schedule

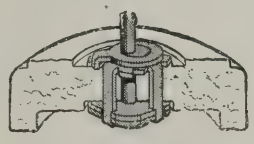
Watts	Volts	Lamp	Bulb	Lumens	Lumens per watt
15	60–65	mazda "B"	S–17	137	9.14
15	60–65	mazda "B"	G–18½	131	8.74
20	30–34	mazda "B"	S–17	195	9.75
20	30–34	mazda "B"	G–18½	185	9.25
25	60–65	mazda "B"	S–17	239	9.57
25	60–65	mazda "B"	G–18½	221	8.85
50	60–65	mazda "B"	S–19	506	10.1
50	60–65	mazda "B"	G–30	515	10.3
75	60–65	mazda "C"	PS–22	993	13.23
100	30–34	mazda "C"	PS–25	1,676	16.76
100	60–65	mazda "C"	PS–25	1,461	14.61

Meaning of the Word Lumen.—The table shows the quantity of light generated by each lamp expressed in lumens. A lumen of light flux is the flux emitted in a unit solid angle by a point source of one candle power. (A. I. E. E. standardization rule 857.) That is, a lumen has been agreed upon as that quantity of light flux which is radiated in a unit solid angle from a one candle true point source.

A unit solid angle is the unit of solid angular measurement. It may be defined as that solid angle, subtended at the center of a sphere of unit radius by a unit area on the surface of the sphere. Also a unit solid angle may be defined as the solid angle subtended at the center of a sphere by an area on its surface, equal to the square of the radius. There are 12.57 unit solid angles about any point in space; that is, any sphere contains 12.57 unit solid angles.

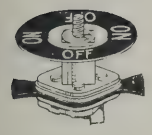


Contact Jaws on Porcelain Base

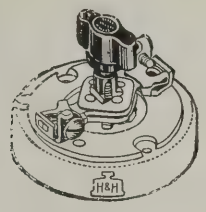


Section of Base Showing Eccentric Spindle

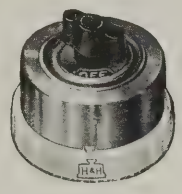
Hard Rubber Handle



Switch Blades and Indicator



Switch Complete Cover Removed



Switch Complete With Cover

Fig. 16—Parts of a Snap Switch

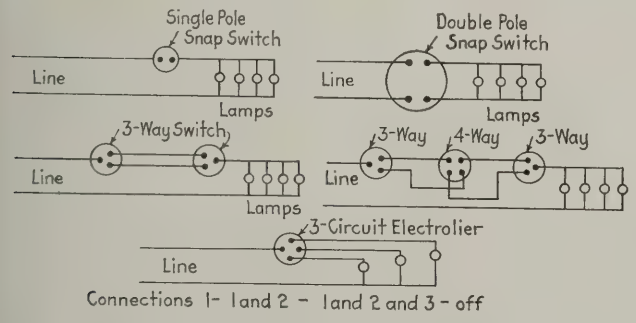


Fig. 17—Circuit Diagrams Involving Snap and Push Switches

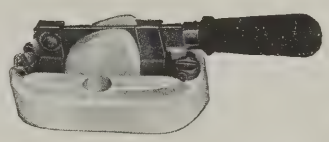
Electric Fans for Passenger Cars

There are two types of fans in general use, the ceiling type and the bracket type. The ceiling type is mounted in a single row along the center line of the car. Bracket fans are mounted on the bulkhead, one at each end of the car and direct the currents of air down the center of the car.

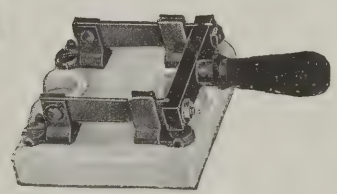
The Safety Ceiling Fan, Fig. 14, controls the direction and distributes the air blown from it. It consists of a motor, an air propeller, an air deflector or distributor, a supporting base and a frame or cage for proper assembly of the parts. The air deflector consists of a series of small parallel planes arranged in two sections within a circular band. These planes are so disposed at an angle to the air propeller as to direct the air movement into the form of a cone when the planes are rotated about the axis of the fan. The maximum velocity of the air is within a zone of 30 deg. to 45 deg. to the perpendicular and tapers off to zero directly beneath the fan and at 60 deg. to the perpendicular. The planes of the air deflector are arranged symmetrically each side of the axis so that when they rotate they produce a movement of the air at intervals of about twenty times a minute. This feature of intermittent breeze eliminates that steady gust of air common to many types of electric fans. The current consumption of this fan is 75 watts. The Safety fans in some cars are equipped with lighting fixtures, as shown in Fig. 15.

Single Pole Push Button Switch

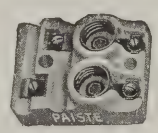
Single Pole Push Button Switch



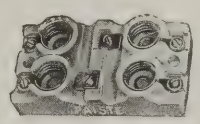
Single Pole Single Throw Knife Switch



Double Pole Single Throw Knife Switch



Plug Cutout 2-Wire Branch



Plug Cutout 2-Wire Double Branch

Fig. 18—Push Button and Knife Switches. Plug Cutouts

Switches and Cut Outs

Snap Switch.—Fig. 16 shows the various parts and a complete snap switch. The snap switch blades are of the knife type and the contact jaws are of spring bronze. The switch is actuated by a spring. As the hard rubber handle is turned the spring tightens and the eccentric on the spindle forces the stop out through the cam point, where it is released just when the spring is at proper tension to throw the blades. In this manner the blades are thrown to the "on" and "off" position, as desired. A disc indicator turns with the switch blades and shows the

position of the switch through a small hole in the switch cover.

Single Pole Snap Switch.—A single pole snap switch is connected in one side of a circuit and controls the circuit by opening and closing the one line.

Double Pole Snap Switch.—A double pole snap switch is connected in both sides of the circuit and controls the circuit by opening and closing both lines.

Three Way Snap Switch.—A three way snap switch has three points—a main and two auxiliary. The main point is thrown in contact with one of the auxiliary points and then the other alternately. Three way switches are used in many ways. They may be used in pairs, where, by the use of two three way switches a circuit may be controlled at two points.

Four Way Switches.—Four way switches have four points of contact. One or more four way switches in conjunction with two three way switches may be used to control a circuit at as many points as desired.

Electrolier Switches.—Electrolier switches are used in many ways. By their use fans may be operated at various speeds, and the individual lamps of a group may be controlled in various combinations by successive snaps of the switch. Circuit diagrams, in which all of these switches are used, are shown in Fig. 17.

Push Button Switches.—The push button switch is constructed on the same principle as the snap switch, having knife type switch blades and spring bronze contact jaws. The contacts are operated by a spring when the button is pressed. The button with the pearl center indicated current "on." Push switches are manufactured in the same types as described in the snap switch.

Knife Switches.—A knife switch consists of a porcelain or slate base upon which is mounted the knife blades, spring contacts and terminals. The blades are equipped with an insulated handle for operating. Knife switches are used to control circuits which carry heavy currents. Fig. 18 shows single and double pole single throw switches, respectively. Double throw knife switches are used for special applications, such as throwing a power or lighting circuit from one source of current supply to another, etc.

Plug Cut Outs.—Plug cut outs are connected in the lighting and fan circuits to protect them. They consist of a porcelain base with receptacles that carry plug fuses, and have suitable terminal posts.

Temperature Rise in Headlight Generators*

Curves Plotted from Tests Made Show That Excessive Armature Heating Is Due to High Brush Pressure

SINCE the application of electric headlights to steam locomotives, many questions have arisen in connection with the maintenance of locomotive electric headlight equipment. The subject discussed in this article is the temperature rise in a steam turbo-generator set and its relation to the heat of the locomotive which it serves. A 500-watt, 32-volt, d. c., ball-bearing, standard design headlight generator is the type of machine under discussion.

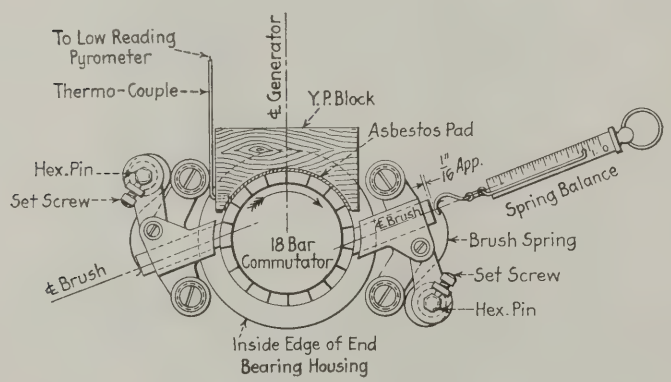


Fig. 1—Method of Determining Commutator Temperature and Brush Spring Tension for the Heat Test of a Headlight Turbo-Generator Set.

In order to make a complete study of this nature, it was necessary to have a 400-deg. F. thermometer for taking the temperature of the steam, which was done by inserting the thermometer in a well in the intake pipe to the turbine. A 300-deg. F. thermometer was used to take the temperature of the field coils and a similar thermometer was used to take the air temperature of the test room. The voltage across the armature was measured with a Weston voltmeter. The tension of the brush springs was obtained with a spring balance graduated in pounds and quarters up to ten pounds. Commutator temperatures were taken with a 500-deg. pyrometer which had a special constructed thermo-couple. The thermo-couple was made of five flexible iron and German silver couples in series each so arranged as to lay beside the other and insulated with double cotton treated with sodium silicate. During all test work this sensitive couple was kept heated by placing it near the intake pipe of the turbine, to a temperature slightly lower than the anticipated temperature of the commutator, so that when applied to it a minimum of time would be required for it to register a constant temperature. When a commutator temperature was to be observed the turbine was stopped and the couple applied to the commutator, as shown in Fig. 1, with an asbestos pad placed over it to reduce radiation. The thermo-couple and pyrometer were calibrated to a 400-deg. F. laboratory thermometer before and after the tests. By the use of the thermo-couple method very accurate temperatures of the commutators were obtained.

The test was divided into three parts in order that the performance might be observed under the average as well as the most severe conditions. The first section of test was conducted on the turbo-generator test rack in the shop. The armature used was given a running balance test. The commutator was cleaned, sanded and the mica was under-cut before starting each test. The winding

*Note: A record of tests and observations made on the Cleveland, Cincinnati, Chicago & St. Louis Railway Company by G. W. Ferling and F. K. Mitchell.

leads were soldered into the commutator with 50/50 wire solder, having a melting point of approximately 380 deg. F. The millivoltmeter test when applied showed the armature to be in the best of electrical condition.

TABLE 1

Service	Turbines examined		Condition: Good		Fair		S		SS		SSS		Spring tension, lb., total (Max.): 1–2.5		2.5–2.75		2.75–3.5		3.5–4.5		4.5–6.0	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Passenger	26	28.3	13	50	2	7.7	7	26.9	2	7.7	2	7.9	15	57.7	1	3.7	9	34.6	1	3.7	0	0
Freight	45	48.9	19	42.2	3	6.67	17	37.7	3	6.7	3	6.7	17	37.9	8	17.8	12	26.7	4	8.8	4	8.8
Switching	21	22.8	9	42.8	2	9.5	6	28.6	0	0	4	19.1	11	52.3	3	14.3	3	14.3	4	19.1	0	0
Total	92	100	41	44.5	7	7.6	30	32.7	5	5.4	9	9.8	43	46.6	12	13.1	24	26.2	9	9.8	4	4.3

Table 1 Showing: Condition of turbine armature and spring tensions on brushes of same turbines.
Key— S—Solder thrown from at least one lead.
SS—Solder from at least half of leads.
SSS—Solder from all leads, commutators worn.

For the first run the brushes were adjusted to a spring tension of 1½ pounds by means of the spring balance,

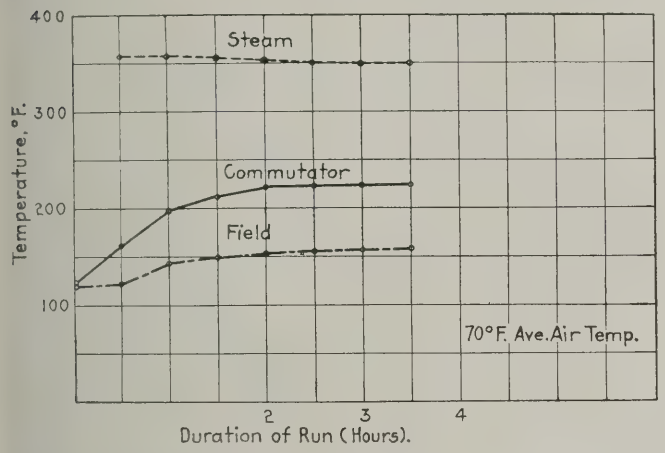


Chart 1—Showing the Relation of the Length of Run to Turbine Temperatures With a Spring Tension of 1.5 lb. total or a Brush Pressure of 2.4 lb. per sq. in. Turbine on Shop Test Rack.

as shown in Fig. 1, care being taken that the scale hook was exactly between the spring and the brush and that the pull was along the center line of the brush. The

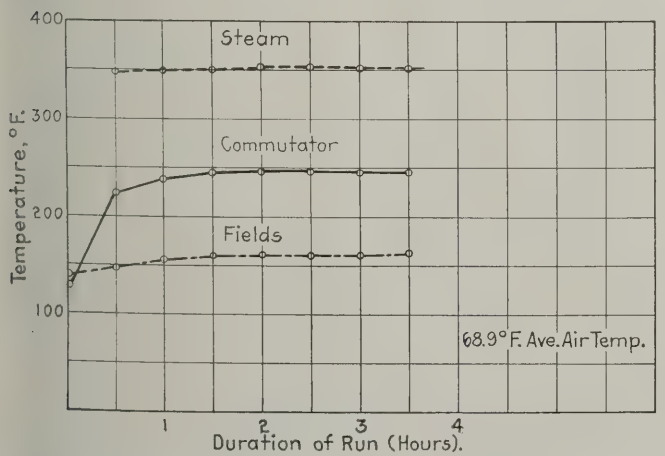


Chart 2—Showing Relation of the Length of Run to Turbine Temperatures With a Spring Tension of 3 lb. Total or a Brush Pressure of 4.8 lb. per sq. in. Turbine on Shop Test Rack.

reading was taken with the brush spring lifted approximately 1/16" from the brush.

Readings of steam temperature, air temperature, and field coil tempterature were taken simultaneously with the temperature of the commutator at half-hour intervals for a period of four hours. The second and third runs of this section of the test were identical with the first, except that the brush tension was made respectively three and six pounds. Charts 1, 2 and 3 show graphically the results of these three tests.

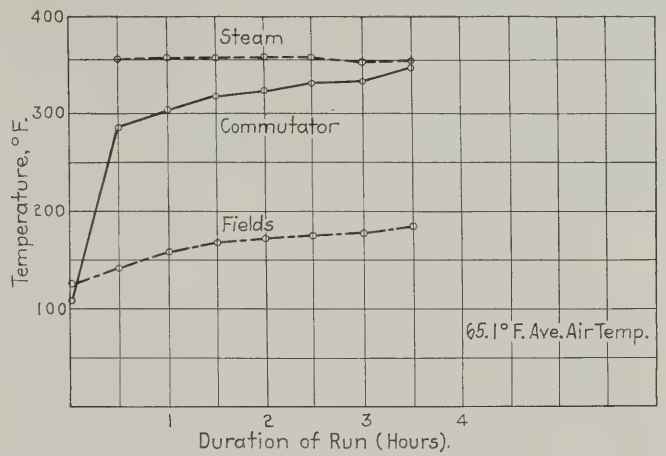


Chart 3—Showing the Relation of the Length of Run to Turbine Temperatures With a Spring Tension of 6 lb. Total or a Brush Pressure of 9.6 lb. per sq. in. Turbine on Shop Test Rack. At the End of the Above Run Although the Commutator was Slightly Out of Round (Solder Had Been Thrown From Five Leads), a 24-hour Uninterrupted Run With 1.5 lb. Brush Spring Tension Disclosed No Further Damage to the Commutator and the Final Commutator Temperature Was 252 Deg. F.

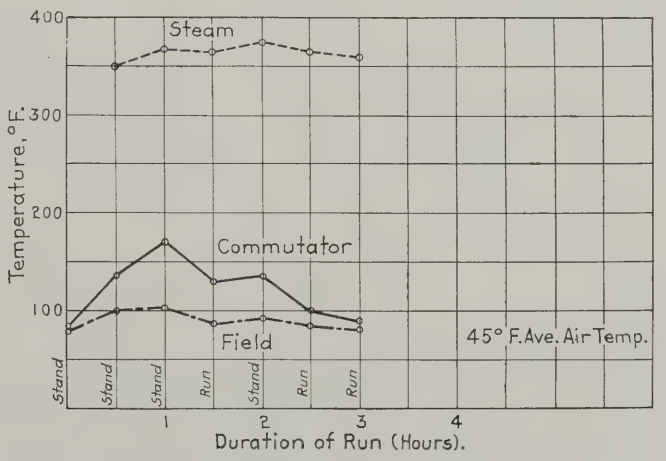


Chart 4—Showing the Relation of the Length of Run to the Turbine Temperatures With a Spring Tension of 1.5 lb. Total or a Brush Pressure of 2.4 lb. per sq. in. Turbine on Locomotive.

The second section of the investigation which was carried on in the field was in the nature of a brush tension

inspection. Ninety-two turbines in operation were inspected, the results of which are shown in Table No. 1.

The third part of the test was conducted with a generator in actual operating conditions on a locomotive in freight service. This test was almost identical with the shop test. A record was kept of whether the locomotive was running or standing when each set of readings were taken, so that the radiation effect could be noted. The results of these observations are shown on Charts 4, 5, 6 and 7.

The load carried in all tests consists of seven 15-watt and one 250-watt lamps, a total of 370 watts. At 32.5

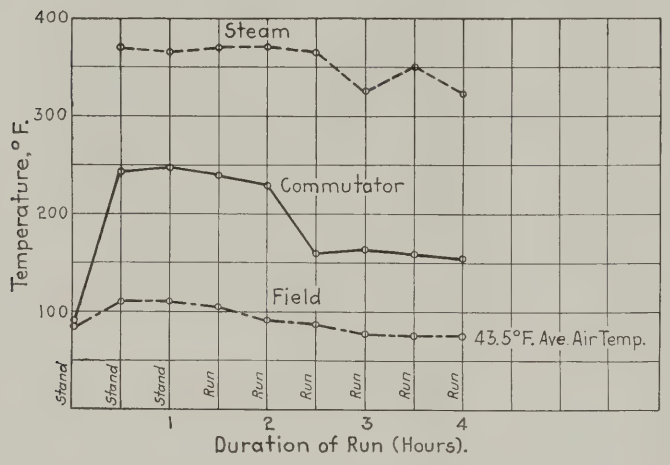


Chart 5—Showing the Relation of the Length of Run to the Turbine Temperatures With a Spring Tension of 3 lb. Total or a Brush Pressure of 4.8 lb. per sq. in. Turbine on Locomotive.

volts this gives a current of 11.4 amperes and with brushes having an area of 5/8 square inch, a current density of 18.2 amperes per square inch. This amount is 51 per cent of the safe value of 35 amperes per square inch, with one volt drop at contact. Consequently, any

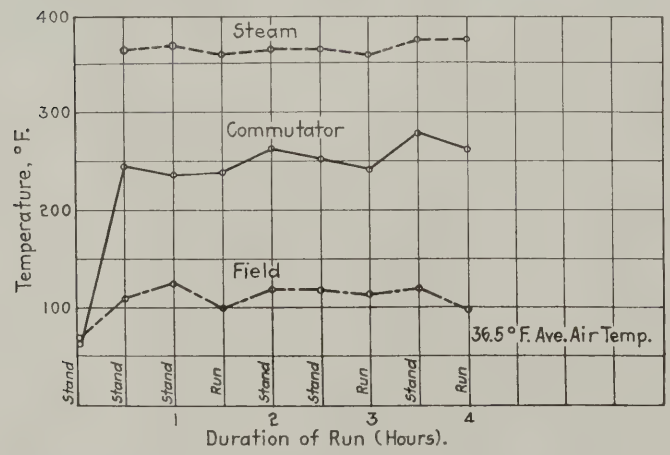


Chart 6—Showing the Relation of the Length of Run to the Turbine Temperatures With a Spring Tension of 4.5 lb. Total or Brush Pressure of 7.2 lb. per sq. in. Turbine on Locomotive.

heating from this source is neglible, as even an inferior grade of carbon brush could operate satisfactorily under the conditions.

In the first test, as well as in all tests conducted, the steam enters the turbine at a temperature of approximately 350 deg. F. and the turbine end of the machine may be considered to be at this temperature. The conduction area between the boiler and the turbine bed plate is only six square inches and the boiler shell is approximately 19 in. by the shortest conduction path from the commutator, whereas, the conduction area between the turbine steam space and the commutator is approximately 5½ sq. in. with the shortest conduction path of 12 inches.

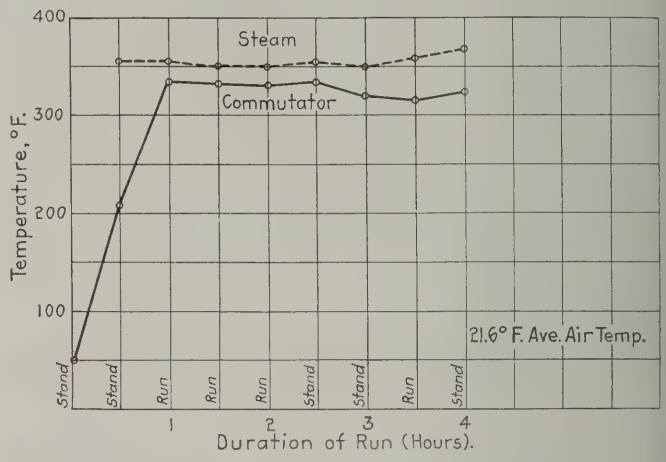


Chart 7—Showing the Relation of the Length of Run to the Turbine Temperatures With a Spring Tension of 6 lb. Total or Brush Pressure of 9.6 lb. per sq. in. Turbine on Locomotive.

If, then, the commutator end, which is the seat of the greater part of all the armature trouble experienced, is considered, the heating effect due to the steam end of the turbo-generator would be greater, either due to radiation or conduction. The field coils would show the higher

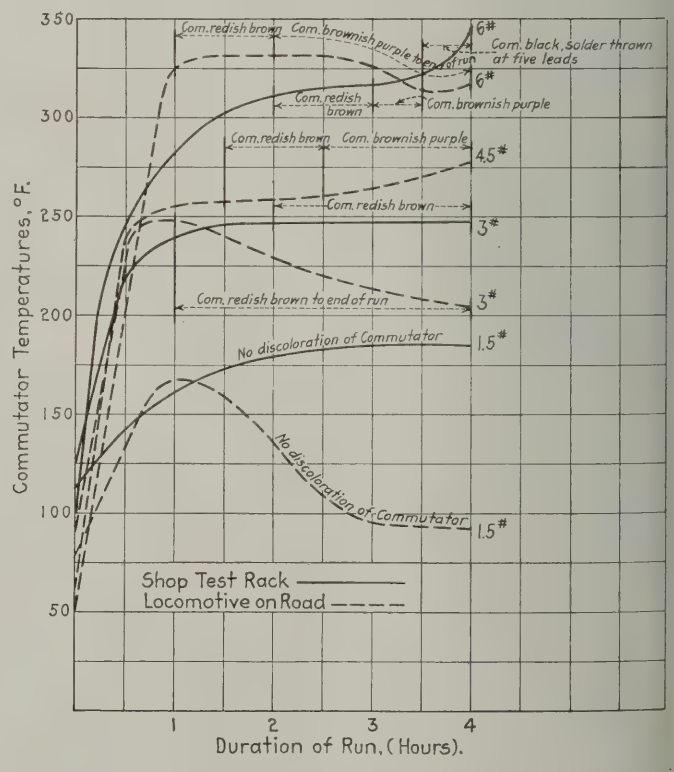

Com. redish brown
Com. brownish purple
Com. black, solder thrown at five leads
Com. redish brown to end of run
No discoloration of Commutator
Shop Test Rack
Locomotive on Road
Commutator Temperatures, °F.
Duration of Run, (Hours).

Chart 8—Showing the Relation of the Length of Run to Commutator Temperatures for Brush Spring Tensions as Shown in Pounds Total at the End of Each Curve.

temperatures and the steam end of the armature would be the first to be affected from heat coming from the steam end. But from a comparison of the field coil temperatures in tests one and four, with brush tension at 1.5 pounds, it will be seen that field temperatures are less

than 160 deg. F., approximately 45 per cent of the temperature of the steam, and in no wise dangerous to the insulation. Reference to Chart 4 will show that at the end of a three-hour road test the temperatures of the commutator and the field are practically the same. It is also to be noted that the radiation due to currents of air and wind while locomotive is in motion is the cause of the reduction in temperature.

A study of Charts 1 to 3, inclusive, will show that

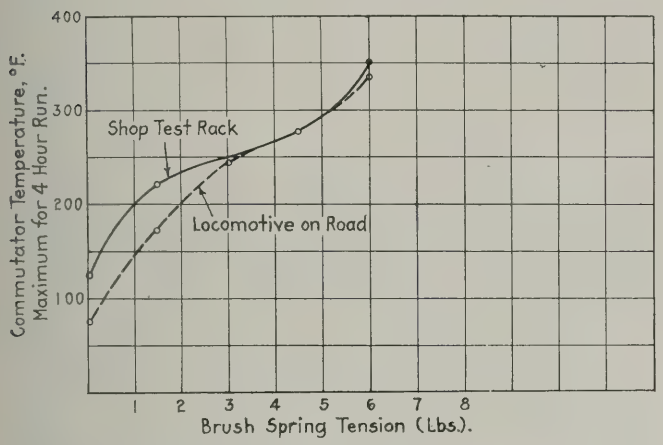


Chart 9—Showing the Effect of Brush Tension on Commutator Temperatures

under normal load with constant steam temperature, speed, and voltage the commutator is dependent upon brush tension, while the Charts 4 to 7 show that temperature is affected, up to three pounds brush tension, by the state of rest or motion of the locomotive. Beyond three pounds brush tension it is interesting to note that the movement of locomotive does not affect the temperature of the commutator, the temperature rise being due to brush tension.

The results of tests one to seven, inclusive, as far as

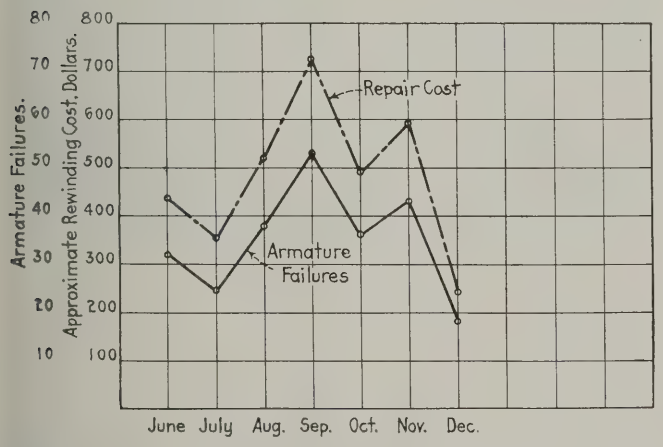


Chart 10—Showing Armature Failures Per Month and Approximate Repair Cost

concerns commutator temperatures for the various brush tensions are shown on Chart 8. It will be noted that for 1.5 pounds brush tension, which is equivalent to 2.5 pounds per sq. in., the heating of the generator is not sufficient to be dangerous to any part, for even the solder used has a melting point of approximately 380 deg. F. It follows, therefore, that the combined other causes of heating, such as brush contact resistance, eddy currents, hysteresis, radiation or conduction from the steam end of the turbo-generator or from the locomotive boiler, is not sufficient to be dangerous to the machine and that the important temperature source is excessive brush tension.

Reference to table No. 1 shows that 44.5 percent of the 92 turbine armatures were in good condition, 7.6 per cent in fair condition and 32.7 per cent were just starting to throw solder, 5.4 per cent had thrown solder from at least half of the leads and 9.8 per cent had thrown solder from all the leads. The brush spring tension on the same turbines shows that 44.6 per cent were 2.5 pounds or less, 13.1 per cent were between 2.5 pounds and 2.75 pounds, 26.2 per cent were between 2.75 pounds and 3.5 pounds, 9.8 per cent were between 3.5 pounds and 4.5 pounds and 4.3 per cent between 4.5 pounds and 6 pounds. From these results it may be seen that there is a very close relation between the brush tension and the condition of the armature and that this condition is dependant upon the brush tension. Chart 10 shows the armature failures per month for seven months ending Dec. 31, 1920. Note that these failures have decreased during the month of December. It is also to be noted that the number of armature failures is not dependent on the air temperature to the same extent that it is to the length of time the turbine is in use for the failures during the summer months average only 31.3 per month, as compared with 44 per month for autumn, which, even though colder, have many more hours of darkness. The decrease in armature failures during the month of December is attributed to closer inspection and adjustment of brush tension, for it has been clearly demonstrated to all in charge of headlight maintenance that temperature rise in headlight armatures, melting the solder, etc., is not due to the heat from the locomotive but from excessive brush friction obtained by high brush tension.

New Suburban Steel Cars for the Lackawanna

In keeping with its general policy of replacing wood passenger coaches with steel equipment the Delaware, Lackawanna & Western railroad has recently placed in its suburban service 30 steel passenger cars and 5 steel combination smoker and baggage cars. From the fact that the cars are practically the same as the other steel equipment operating in this service it is indicated clearly that the type of coach which the Lackawanna has adopted has given entire satisfaction. The new cars are equipped with cane seats and are capable of accommodating 90 passengers. The interiors are finished in imitation mahogany.

Lighting

The lighting arrangement, as may be seen from the photograph, consists of one row of nine single lighting units. The fixtures used are manufactured by the Safety Car Heating & Lighting Company, the glass bulbs or shades being known as "Corona 3876." These lighting units are spaced 6 ft. apart, the entire length of the car, and each unit is equipped with one 30-volt, 50-watt, Type C Mazda PS. 20 bulb. The resulting illumination is most excellent. In addition to the row of lighting units down the center of the car there are two 25-watt lamps, one on each platform, and one 25-watt lamp in the toilet. The platform lamps are mounted in recesses in the car ceiling and are located directly over the center of the

platform. By mounting the lamps in this manner the liability to breakage is very much less and still the illumination is ample to meet the requirements.

All of the new cars are equipped with two-wire train lines of No. 4 B. & S. stranded conductors. Jumbpers for connecting one car to another in the event of light failure on any car are also available. These jumpers are composed of 133 strands of small wire in order to secure a maximum flexibility which may be interpreted as a

One of the New Coaches

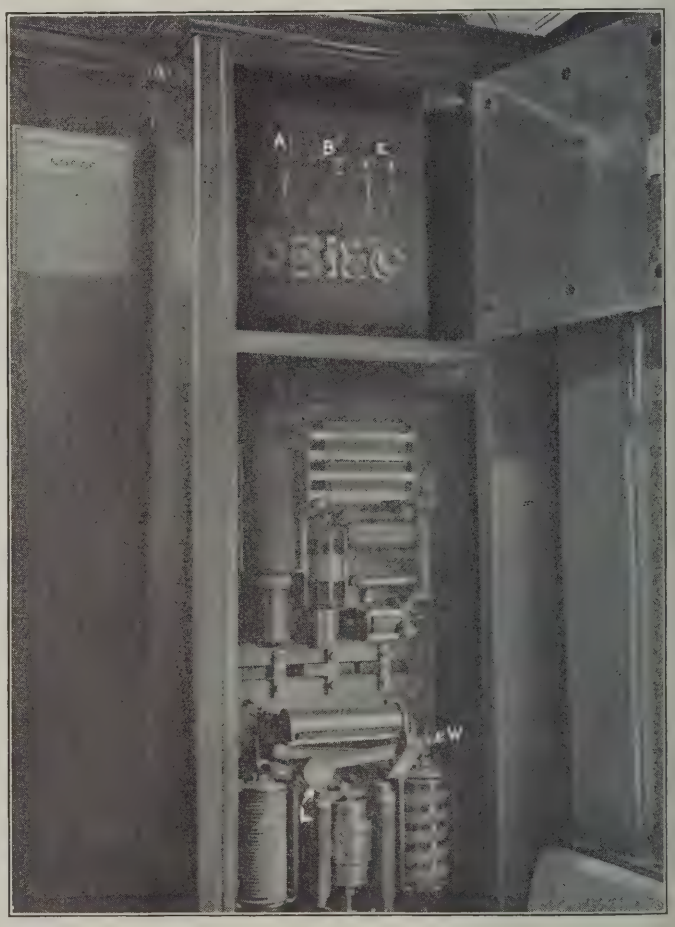
maximum of life. The wiring which supplies energy to the lighting units in the car is carried in a conduit run located between the head lining and the car roof, outlet boxes being spaced every 6 ft. to coincide with the fixtures. In the switching panel, shown in the upper part of one of the photographs, are located two 10-ampere, indicating, double pole snap, switches by which the car

Lighting Arrangement of the New Cars

lighting is controlled. One of these switches is connected to four of the center lighting units and the two platform lights, while the other switch controls five of the center lights and one 25-watt lamp in the toilets. This arrangement divides the load fairly even on the two circuits since one of them has an energy consumption of 250 watts while the other consumes 275 watts.

The double pole knife switches designated as *A, B* and *C* on the photographs are the battery switch, the main lighting switch and the train line switch respectively. The 100-ampere, flat, metal link fuses connected to the lower terminals of these switches are of the type manufactured by the Chicago Fuse Company. The wiring is so arranged that in the event of a fuse blowing the disrupted part will fall away from the live side of the circuit which is connected to the upper part of the switch.

A battery switch *A* connects the two leads of the storage battery to the lighting circuits through the main lighting switch *B*. Current is brought to the switch *B* from three different sources at different times, the usual sources being the battery on the car itself and the generator. A third source is from the battery or generator



Generator and Lighting Panels

of an adjoining car in the case of failure of current supply.

The generator regulator panel is of the Gould type B-B-9-B and the lamp regulator is the M-2 type. Ordinarily, the panel is adjusted at 36½ volts, open circuit. With this adjustment a current of 45 amperes plus the lamp load is developed by the generator. With heavy current flowing the differential winding on the potential coil allows the generator voltage to rise to approximately 39 volts. This is sufficient to maintain the lights satisfactorily during the spring, summer and fall months. In the winter time, however, due to the lower temperature prevailing, the battery requires higher voltage in order to charge it to the same degree as in the summertime. For this reason the voltage limit must be set higher in order to

compensate for the higher voltage required to charge a cold battery. On the other hand, the potential coil being cold, the panel has a tendency to operate at a lower maximum voltage. This also must be compensated for and it has been found that a weight, *W*, 4 oz., sufficient to raise the voltage setting of the panel about 4 volts is required on the voltage lever arm. About November 1, if the weather is becoming severe, this weight is dropped on the pin of the voltage coil lever arm. Another weight *L*, 2 in. in diameter and 1 in. thick is made of iron and is mounted upon a stud which is screwed into a hole bored in the current lever arm. The purpose of this weight is to raise the ampere setting from 45 amperes to 60 amperes. This adjustment has been found necessary in suburban service on account of the very short runs. More current is required by the cars in this service throughout the year and this additional weight on the current lever arm automatically takes care of any excessive burning period of the light and consequently prevents the exhaustion of the battery.

The battery equipment of the new cars consists of 16 lead cells housed in 8 double compartment, lead lined trays of the skeleton type. These trays have chest handles. The cells are of the Gould C L S 13 type, of 300 ampere hour capacity equipped with hard rubber covers. The trays are equipped with porcelain skids.

The Reason Why Some Fusion Welds Fail*

Hardening Effect of Welding Heat Graphically Demonstrated and the Effect of Annealing Shown

By T. D. Sedwick
Engineer of Tests, Chicago, Rock Island & Pacific, Chicago

IN case of poor results from fusion welding shown either by laboratory tests or actual service, the inclination is to attribute such results to the material used, the method of making the weld, a poor operator, or the contributing effect of all three of these factors.

But there are other points that enter into the final results, and two of the important ones are as follows:

First—Was the metal in the casting or forging in such a physical condition that it was fit to be welded and afterwards give good service; did the metal originally fail on account of the presence of segregation of the various chemical elements; did it contain blowholes, porosity, or were there thermal stresses left from the original forging or casting operations; had the previous service fatigued the metal to the extent that it was inherently weak?

Second—Was the original metal adjacent to the weld deleteriously affected by the welding operation?

Some take the first mentioned factors into consideration, but I do not believe that very many, particularly the shopmen, give much thought to any action which may take place on the original metal. Tests and observations made on failed material and special test specimens have shown that welds fail, although good conditions prevail in all other respects.

Investigation on various welds has shown that in the majority of the cases, especially in certain classes of material, the welding heat or the process of preheating has affected the metal in the sections being welded, causing a transformation of the physical structure of the steel, and in case of localized high temperatures the main body of the material absorbs the heat so fast that there results a quenching action on the heated metal. In the majority of instances the extreme hardening action will be localized near the surface immediately adjacent to the added metal. In some cases of preheating it has been shown that the high temperature causes a change in the physical structure of the metal, and while it is not usually so localized as in the case of the action of the welding heat alone, thermal stresses are set up in addition to those created by the heat of the welding process. These conditions have been found in material of thick sections where the heat would not be readily absorbed throughout the section and where the chemical content, especially the carbon, was such that it rendered the metal readily susceptible to structural changes, resulting in a hardened condition.

To illustrate some cases of this kind photographs have been secured showing several special tests and also some examples of failed material. A great many of these tests were made to demonstrate to the shopmen, that in the majority of the cases proper annealing should be done after the weld has been completed and that a thorough annealing would improve the physical condition of the metal, thereby causing it to render better service; this thorough annealing to be made by placing the metal in a furnace and giving it a soaking heat and then cooling it so that the whole mass could adjust itself to a uniform condition throughout.

The idea of causing a self or automatic annealing to take place by preheating is going at the proposition backwards and trusting to luck that we have not done more damage than good. It is necessary at times to preheat to take care of the shrinkage strains which might be set up in certain sections during the cooling after welding. What I am advocating is that after this has been done, we follow out a thorough annealing program. In this way any strain or hardened condition that has been set up by preheating, or by the welding heat, will be eliminated and we will then have a product the service of which will depend mainly on the quality of the material in the weld, and the perfection of the weld.

There are certain zones in any torch flame that are of a higher temperature than others, and as it too often happens that a sufficient length of time is not taken in preheating to permit a soaking heat, more or less locally heated areas are produced that multiply the thermal

*From a paper read before the American Welding Society, Chicago Section, December 22, 1920.

stresses not eliminated during the subsequent period of cooling.

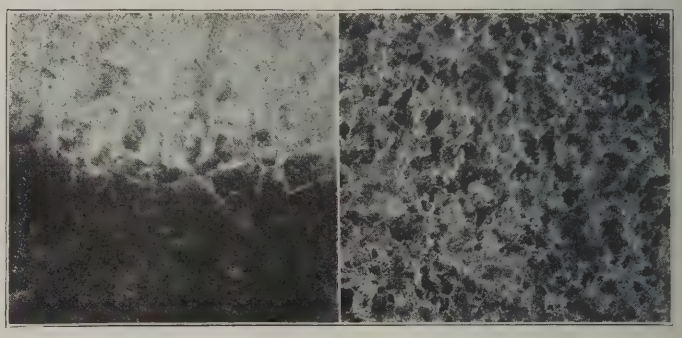
In the majority of the shops, especially the larger shops, where special annealing furnaces have not been installed, there are always some furnaces of sufficient size in which at least the smaller castings and forgings could be annealed, and this annealing could be done at

Fig. 1—Etched Cross Section of a Failed Piston Rod; the Crosshead Fit Had Been Built Up by Electric Welding

a comparatively low cost. At the close of the day, as space is being left unoccupied by the regular work of the shops, the welded material could be placed in the furnace and be annealed over night without any material increase in the cost of fuel. This plan would not check production of the regular work.

Too little attention is given to annealing in general even in cases where no welding is done. In reclamation plants, where old material is re-worked, a worn out or failed forging will be reforged. When originally forged thermal stresses may have been set up in this material and not removed, or the material may have been overheated or even burnt. Later, during its actual service, fatigue stresses and unsatisfactory physical structure may have been produced. On reforging, further stresses may be set up and then without annealing to refine the grain and remove these stresses the forging will be returned to service. While it may give some service, if we had gone a little further and treated it properly, the extended service, in my opinion, would have been sufficiently great to more than justify any extra trouble or expense involved in a final annealing after forging. The same thought applies to welding of failed material.

There are a great many misconceptions of the process of annealing and a great many shopmen fail to observe the rule that it requires time for a piece of steel to adjust

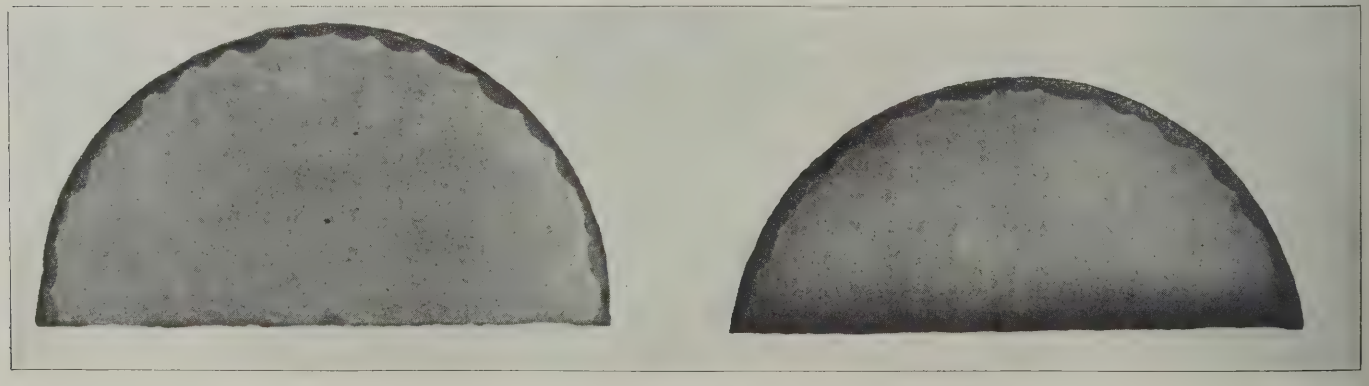


(a) (b)

Fig. 3—Microphotographs of the Metal in the Piston Rod before Annealing; (a) the Added Metal and the Heat Affected Area; (b) Normal Structure at Center of Rod

itself to the annealing temperature and be uniformly heated throughout. For instance, on one particular forging which the workman was instructed to anneal thoroughly he advised that he was doing so. But later it was found that he was simply sticking the forging into a blacksmith fire so that the welded area was buried in the fire. Under such conditions, while the extremely localized, highly affected areas will be removed, minor stresses will be set up back along the forging. To do the job right the forging as a whole should have been subjected to the annealing heat.

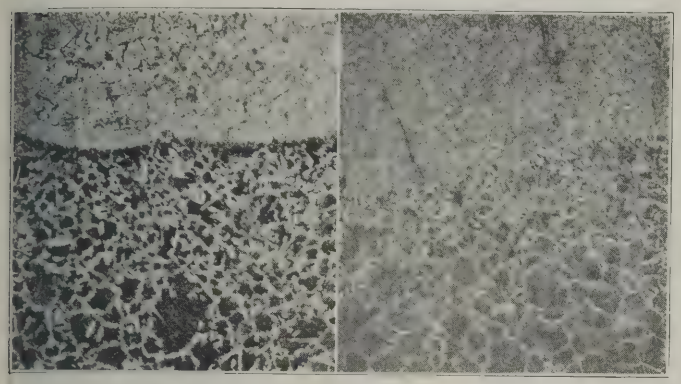
With such methods it is hardly fair to expect 100 per cent service out of material to which we have added or in which we have produced unsatisfactory conditions rather than reduced them. I am not looking at this matter from a strictly theoretical standpoint; the tests and the various failed material which have come to our attention justify these remarks. In a great many cases the only reason that a new forging may give good service



(a) (b)

Fig. 2—Two Halves of the Face Opposite to That Shown in Fig. 1 After Annealing; (a) Cooled in the Furnace; (b) Cooled in the Air

is because the designer has allowed for such a great factor of safety that the shopmen can do almost anything with the material, and there will still be some service left. Assuming that a designer had originally made provisions for a factor of 10 and later the section was broken and



(a) (b)

Fig. 4—Microphotographs of the Two Pieces Shown in Fig. 2, after Annealing; (a) Cooled in the Furnace; (b) Cooled in the Air

welded, this weld in reality may have a factor of five. The designer attempts to take into consideration not only the ordinary service requirements, but abnormal requirements that the material might need in case of emergency. If we have reduced this factor 50 per cent, the material

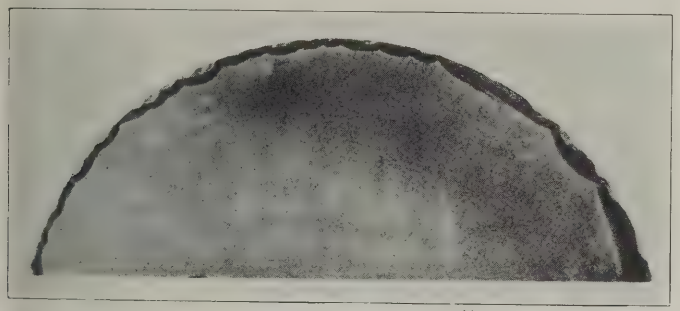


Fig. 5—Example of the Effect of Erratic Action by the Operator on the Uniformity of Heat Penetration

might be able to go along in ordinary service with safety but for the emergency cases we may have eliminated the safety margin entirely. Sometime during the life of the material, it is going to run into extreme conditions. Then, if we have not taken the proper precautions, it will fail.

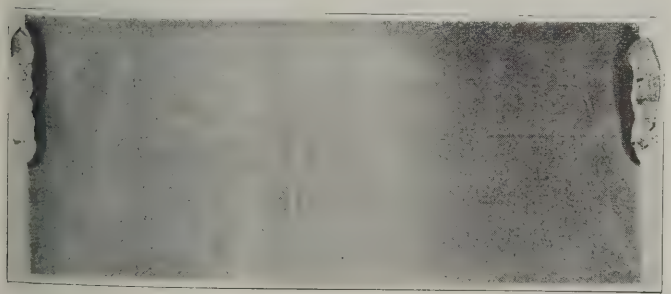


Fig. 6—Hardening Effected by Adding Metal Without Preheating—Electric Arc

Even where the welder has increased the cross-sectional area the failure can be traced to some of the conditions mentioned above.

The photographs were taken in connection with some of the tests already mentioned, to illustrate the zones affected by the heat and the hardening effect of the welding operations. The method of bringing out visibly these hardened areas or structural differences without magnification involves the same procedure that can be used in checking the extent of the hardened or tempered areas in tools, such as chisels, hatchets, etc., and is compara-

Fig. 7—The Hardness Removed by Annealing

tively simple. The surfaces are given a rough polish and dipped in nitric acid of specific gravity 1.13, or where this is not practicable the acid may be poured over the steel.

The hardened areas referred to, in a great majority of steels will correspond to the hardness that would have been produced had the steel been heated and quenched.

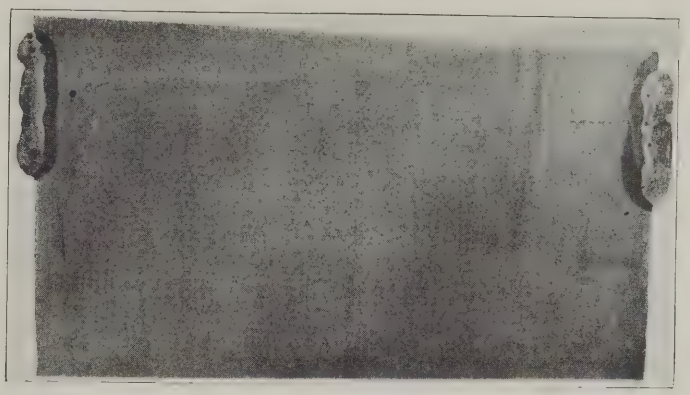


Fig. 8—Metal Added After Preheating With the Arc

In some of the tests illustrated strips were taken from the specimens so as to embody metal from the extremely hardened zones only, and then from adjoining positions

Fig. 9—Hardness Produced by Preheating With the Arc—No Metal Added

progressing successively into the unaffected metal. It was found that in the zones where the hardened condition was highly localized these strips would not bend

over 15 deg. before breaking or snapping off, but after annealing they could be bent flat on themselves, the same as the original metal.

A failed piston rod on which the cross head fit had been built up by the electric welding process is shown in Fig. 1. The photograph shows the added metal on the outer area around the circumference and between this and the interior metal in the rod is a scallop-shaped area

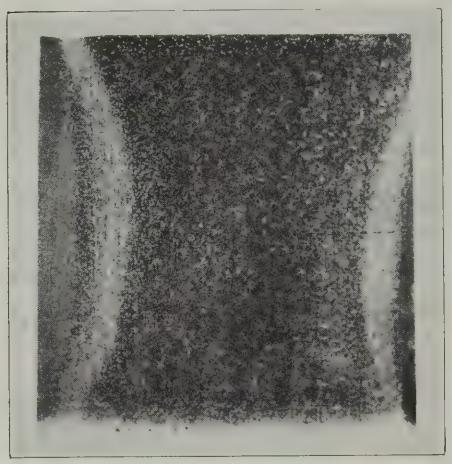


Fig. 10—Hardening Effect Produced by Preheating with Oxy-Acetylene Torch —No Metal Added

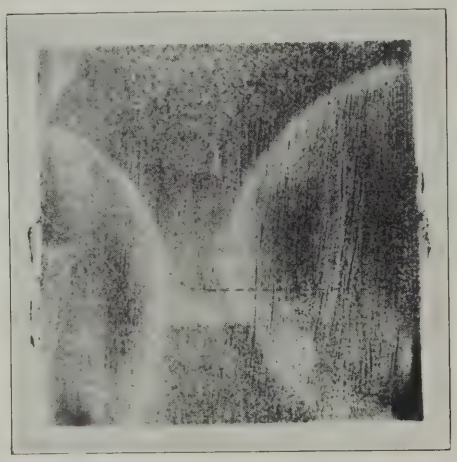


Fig. 11—Hardness Produced by Adding Metal with Oxy-Acetylene Torch after Preheating

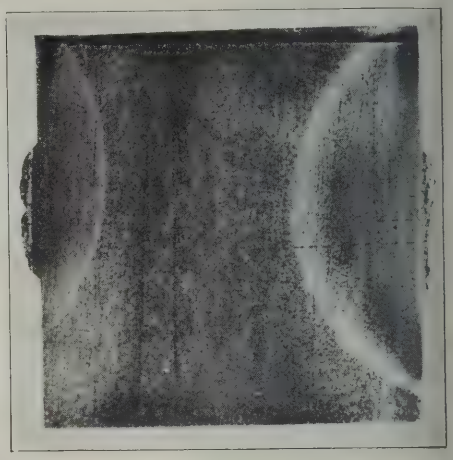


Fig. 12—Affected Zones Caused by Adding Metal with the Oxy-Acetylene Torch without Preheating

affected by the welding heat. This represents the condition of the metal in the rod at the time of the failure. The average scleroscope hardness of the added metal was 49, of the heat affected area 80, and of the metal in the rod proper 50.

The face of the same cut opposite to Fig. 1 was cut in two and both pieces annealed, one-half being allowed to cool in the furnace and the other half in the air. It will be noted in Fig. 2 that the hardened area between the added metal and the parent metal has been eliminated in both cases.

The scleroscope hardness of the added metal in the

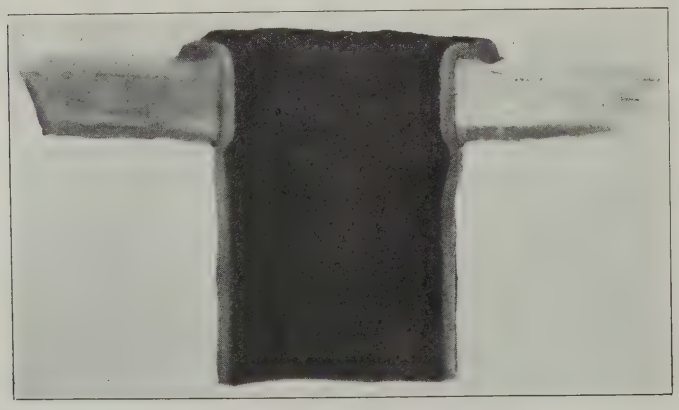


Fig. 13—Etched Section Through a Boiler Tube Welded to the Sheet; Metal of the Sheet Unaffected

piece cooled in the furnace was 38 and of the metal in the rod, 55. The scleroscope hardness of the added metal in the piece cooled in the air was 38 and of the metal in the rod, 57.

The fact that the added metal in these two photographs is shown in black should not cause it to be confused with the darkened area on Fig. 1 as in the latter two cases this was a matter of etching to differentiate between the added metal and the metal in the rod proper.

Fig. 3 shows microphotographs of the metal in the rod before annealing; *a* shows the added metal and the heat affected area in the rod, *b* the normal structure in the center of the rod, all at a magnification of 100 diameters. Figs. 4*a* and *b* are the microphotographs (100 diameters) of the two annealed pieces shown in Fig. 2. Both were annealed for three hours at 1,500 deg. F., after which *a* was cooled in the furnace and *b* in the air.

Both show the added metal and the structure in the rod proper, the heat affected area having been eliminated

Fig. 14—Example of Metal Too Poor to Weld

by the annealing process. There is less segregation of the ferrite around the grain boundaries in the piece cooled in the air than in the one cooled in the furnace.

As a further illustration of the variation of the hardened zone, Fig. 5 is an etched cross-section of another piston rod on which the cross head fit had been built up, the rod originally being heat treated Nichrome steel. Attention is called to the variations in the area of this hardened zone in the parent metal. On comparison with the one first rod shown, an unusually uniform movement and metal application by the welder is evident. It has occurred to me that an etching method similar to this

might be adaptable for grading or examining welders as to their proficiency as well as for giving some indication as to the condition under which they were working.

The next few etched sections were made in an investigation to determine if a system of preheating could be developed to eliminate the hardened zones or heat affected areas created either through the preheating or the welding heat.

Fig. 6 is a crank pin, on which no preheating of any kind was done. The scleroscope hardness on the added metal was 33, on the hardened zone 58, and on the rod proper 46. The metal was added with an electric arc. Fig. 7 shows the previous piece after annealing, the added metal showing a hardness number of 34, and the pin metal proper 45. Fig. 8 is a piece of crank pin steel to which the patch was made after preheating the parent metal with the arc, resulting in the hardness numbers of 35 in the added metal, 50 in the hardened zone, and 47 in the rod. The metal was added with the electric arc. After annealing, the hardened zones were removed; the hardness number in the added metal was 35 and in the rod 45.

Another piece of the pin was preheated in the blacksmith furnace and metal added by the electric process; in this case the hardness number in the added metal was 34, in the hardened zone of the pin 59, and in the body of the pin 46. After annealing, as in the previous instances, the hardened area was eliminated, resulting in a hardness number in the added metal of 34 and in the rod of 45.

Fig. 9 shows a pin which was preheated with the arc, but no metal added, resulting in a clearly defined hardened zone with a hardness number of 64, the body of the rod showing 44. After annealing of this piece the hardness was uniformly 45 out to the edge of the piece.

Metal was added around the section of a locomotive frame with the electric arc, without preheating. The metal was added in three layers with the idea that the succeeding layers might exert an annealing action on the affected area. The hardness number in the added metal was 34, in the affected area 57, and with the parent metal 47. After annealing this piece the affected zone was removed. The same frame member was preheated with the electric arc and metal again added in three layers, as in the former case, without showing any improvement in the hardening effect of the welding heat.

Attention is called to the extension of the action of the arc ahead of the added metal, which may be observed in these photographs. It will be noted that the hardened zone extends about the same distance in front and back of the points where the welding operation starts and stops as it does beneath the weld. In a great many cases, in fact in the majority, it appears that a fracture will start by an initial check through the affected zone immediately back of or in front of the added metal, although there have been cases that unquestionably were a detail fracture starting from the area underneath the added metal. Fig. 10 is a piston rod which was preheated with the oxy-acetylene torch, no metal being added. The heat affected area is shown by the shaded zones, with a maximum hardness in the affected zones of 53, whereas the normal hardness in the rod was 44. After annealing, this piston rod showed a normal hardness of 45 throughout the rod section.

In the case shown in Fig. 11 the piston rod was preheated according to the regular practice and metal added by the oxy-acetylene process, producing the affected zones shown. The hardness of the added metal in this case was 32, in the affected zones 53, and in the rod proper 44. On annealing this piece the affected zones were removed; the added metal then showed a hardness of 34 and the rod 44. Fig. 12 shows the same affected zones when the metal was added by the oxy-acetylene process without preheating. The added metal shows a hardness of 32, the affected zones 53, and the body of the rod 42. On annealing, the affected areas were eliminated, resulting in a hardness number in the added metal of 35 and in the rod of 45.

A worn tire flange, with an original scleroscope hardness over the section averaging 49.2, was built up by electric welding. Before annealing the added metal had a hardness of 18, the hardened area of the original metal 67, and the body of the flange 48. After annealing, the hardness of the added metal was 20, that of the affected area 46 and the body of the tire 48.

The average of several transverse tests on pieces of rail in which bolt holes were drilled, showed an average depreciation of the transverse strength of about 25 per cent as compared with the solid section. Where these holes were cut with the acetylene flame, this depreciation was 38 per cent.

The photograph, Fig. 13, of the boiler tube welded in the plate and then etched, does not develop the highly affected zones shown in the previous views. In this particular case the hardness number of the plate was 45, in the tube 50, and in the added metal 45. Even if the welding heat did cause unsatisfactory conditions to exist along the lines in question, the service conditions would in themselves constitute more or less of an annealing process.

Fig. 14 is a piece of a member of a truck side frame which had been welded with the acetylene flame. It shows an unusually large area affected by the preheating and welding heat, particularly the white zone about the center of the section, which showed a penetration through the entire section. The metal is excessively porous and this casting should, in my opinion, never have been welded unless it was possible to cut away this area entirely.

I do not want to leave the impression that all welds fail on account of the structural changes due to the heating, or that I am advocating not doing any welding at all, or that I am in favor of any one particular process of welding. All the various methods of welding have their proper fields, and a great deal of profitable work can be done with them. However, if the points mentioned are taken into consideration by the party laying out the welding work, our welds will certainly show fewer failures.

Safety First—If every man would give a glance, and warn the man who takes a chance; if every man were pennywise, goggles he'd wear to guard his eyes. If every man in chances wild would stop and think of wife and child; if every man could but observe the good that follows steady nerve; if every man to dodge the ward, would pull that nail from out the board—then we'd all together make safety first.—*Charles E. Bradley, S. P. Co.*

Cast Iron Welding

By C. J. Holslag
Chief Engr. Electric Arc Cutting & Welding Co.

Cast iron differs from steel in that it contains about 3.5 per cent carbon, whereas steel, even the hardest, contains less than 2 per cent carbon, and 98 per cent of all steel in the world has less than 0.2 of one per cent carbon. The cast iron with the same amount of carbon in it may have the carbon in two forms, i. e., combined and uncombined. In the combined form the cast iron is very hard. In the uncombined form it is comparatively soft, easily machineable, and can be caulked. Various degrees of hardness range between these two limits according as to whether all of the carbon has flaked out of the combination into graphite, or whether some remains. The condition as to whether the graphite will be separated, or in combination, depends on the rapidity of the cooling from a temperature just above the red heat. If it is cooled rapidly there will be no time for the graphite to come out of combination. If it is cooled very slowly, the graphite will all come out of the combination and various degrees of hardness are obtained by the difference in the time of cooling. A form of cast iron called malleable cast iron is rapidly becoming extinct. After weeks of slow cooling the graphite settles to the outside and is taken off the cast iron, and it gradually begins to take on the properties of wrought iron. As aforesaid, this is drawn off. Real malleable iron is rapidly going out of use due to the time taken to make it. So-called malleable iron is generally cast iron with very little of the graphite removed. In making a weld on cast iron cold, naturally the cast iron is cooled very quickly, or chilled just below the joint of the weld and sometimes the weld itself will be very hard because of the very quick cooling. This occurs whether welding with a steel electrode or with a cast iron electrode. This chilling, hardening effect can be removed by reheating and annealing in lime or warm sand, or any way to allow it to cool slowly.

Cast iron will not suffer any permanent deformations; in other words, it cannot be bent, stretched or put out of its original alignment in any manner without breaking or cracking. To relieve the stresses, set up in welding cast iron cold, the weld must contract and if the shape of the cast iron pieces is such that one or both ends cannot move in with the weld, something must give. If the weld is one-quarter or less of the section of the cast iron and a good joint is made to the cast iron, the weld will stretch, because, although the weld even if of steel, being four times as strong as the cast iron section, if it is one-quarter or less in area, will stretch and it does not hurt the weld to stretch. It is similar to working steel after casting into forgings and rolled shapes. If the weld can be put on a little at a time, so that its cross section is also less than one-quarter of the cast iron which it is welded to, results can be obtained which will not bend out of the original position.

The foregoing applies to welding with the steel electrode. In welding with cast iron electrode, the relative strengths would be the same, but due to the cast iron weld not being able to stand any deformation, it would crack through the weld. The remedy for this is to preheat the parts to be welded so that they will all contract at the same rate. In this manner welding with a cast iron electrode is much more rapid and more satisfactory than any other process. The arc has a tendency to burn out the carbon in any welding, and there is an especially fertile field where the carbon is 3.5 per cent. We have developed a coating for the electrode which resupplies this carbon by adding an excess so that true cast iron of the same nature as the original is deposited in the weld.

Another method of welding cast iron is to anchor the steel weld to the cast iron by means of studding, so that the weld in contracting cannot pull out of the cast iron no matter what the relative sections. In this manner the weld to the cast iron is made as well as to the steel studs, and the weld is by far the strongest part of the job. This is the method that was used in welding the cast iron parts of the German ships, and was developed by Joseph McAllister of the New York Central R. R.

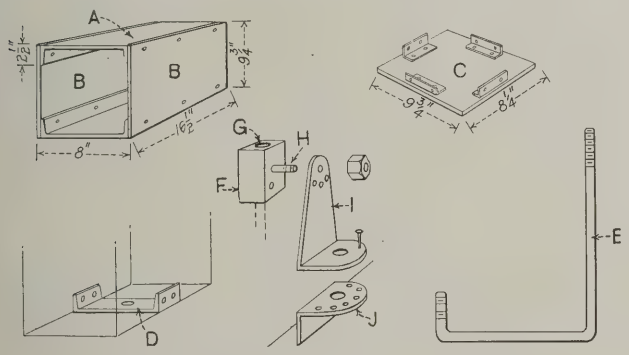
Another method which has a similar basic theory, and is especially useful for sections that are too thin to stud; i. e., automobile cylinders, jackets, crank cases, heating boilers and other cast iron parts complicated in shape, and where no deformation can be allowed, is to run beads at right angles to the crack about eight to ten times the thickness of the weld at the crack, which right angle beads laced back and forth at intervals of four to six times the thickness of the piece hold the weld and adjoining cast iron from separating, so that the contraction takes place in the weld where it does no harm. We have welded automobile water jackets, crank cases, furnaces, etc., in this manner and have yet to be stumped. We have welded automobile water jackets without taking the water out of the engine in emergencies. Sometimes the weld will be stressed beyond its elastic limit and crack, but no precautions need be taken in welding, as this crack will then have steel to hold it. Naturally the less the heat used, the less will be the stress to be taken care of. To that end, use as little heat as possible, and proceed a little at a time, allowing the beads to completely cool before tackling the next one, except in the case of the beads at right angles to the weld, which beads should be put down as nearly as possible at the same time as the intermediate lengthwise beads. In pieces that have cracked and sprung apart and should be brought into alignment this method of crosswise beading, proceeding from the smallest end of the crack, will bring the original pieces into such intimate contact that it is very often watertight before starting the intermediate beading. In order to keep the heat as low as possible a special electrode, whose melting rate is higher than ordinary steel may be used. It will be found that this will aid materially in keeping the stresses down. All of this welding with steel is done without preheating or annealing of any kind, the finish if necessary being ground to size. We have one of our operators who has not seen anything but cast iron welding for so long that he probably has forgotten how to weld steel. The work requires more care, but we have yet to make a failure of any job. In the case of a score inside of the cylinder wall, if our machine can be set at half-primary voltage so that it will draw an arc, but not sustain it, the metal can be deposited in one flash at a time, using the special electrode without cracking the adjacent cast iron. In case the machine cannot be set at half-voltage a foot switch in the secondary circuit or the primary circuit should be opened, as each drop is deposited so as to not use the high heat in depositing the metal. The finishing can then be obtained by grinding.

PRACTICAL STUNTS

A Handy Device for Repairing Lead Battery Tanks

By Revell F. Wilgus

The repairing of lead battery tanks has been one of the many troubles that has confronted us in the car lighting game. Many tanks were scrapped at great expense and many different methods of repairing were used, but none of them seemed to be altogether satisfactory. One of the schemes for repairing involved the use of blocks of wood covered with asbestos, but this arrangement proved to be very unhandy, as only small repairs could be made with it. Moreover, it caused some trouble, as the asbestos worked in with the lead during the process of repairing, and while the tank would stand the leakage test when repaired, it was found that after it was filled with acid and put in service, the acid would eat out the asbestos and cause a leak. The leakage test just referred to is made by placing the repaired tank upside down in a vat of water and pushing it down until the bottom



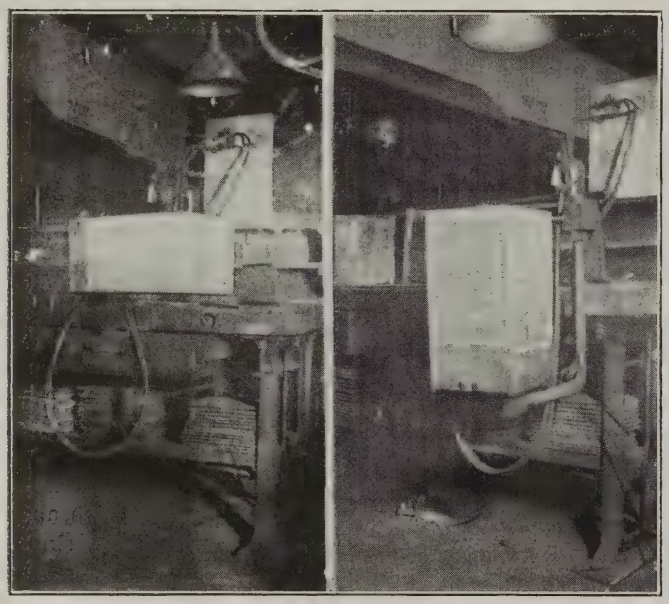
Details of Parts Used in Making the Form

is submerged about four inches. If there still remains a leak in the tank, the air which is enclosed on the inside will immediately make itself manifest by bubbles arising through the surface of the water. After experimenting somewhat with asbestos-covered blocks of wood, an iron form was developed which has overcome all of the troubles which we had previously experienced. This metal form has proved to be a wonderful success. If proper care is taken to clean the lead, and also the filler, no dirt is included in the joint and leaky tanks do not result. The welding flame should be held close to the lead, for by holding the flame in this way the lead not only is prevented from oxidizing, but it flows together much better. If the flame is held close to the work, the lead will have a bright appearance after the weld has been made, whereas if the flame has been held too far away, the surface of the lead will have a smoky appearance. The form which we are using is very substantial, as it is made of boiler steel. It can be turned in a circle or set at any angle desired by the workman and it has the further advantage of always being on the level with the work bench. The process of repairing a tank is usually as follows: Before putting the tank on the form, lay it on the bench and hammer out the sides with a rubber or wooden mallet. It should then be slipped over the form and the sides hammered down on the form so that all sides are smooth. Then take a scraper and scrape the place to weld, mark it off square, and take a wide chisel and cut out the defective part. Next substitute a piece of good lead taken from some old tank that is not worth repairing and scrape it bright and clean. This piece is then placed in the opening and welded on the four corners. The patch being thus held in place, the remainder of the weld is made holding the filler in front and working with the flame close to the lead. As a word of pecaution, it may be said that the fumes from dirty lead are what cause lead poisoning and workmen should wash their hands before putting them about the face, as the lead going into the pores of the skin is very injurious.

Details of Construction

The several sketches shown in Fig. 1 illustrate the manner in which the iron tank form is constructed. First are required two pieces of channel iron 8 in. wide and 16½ in. long, with 2½ in. flanges. These pieces are marked *A* in the sketch. Each flange of each piece of channel iron is drilled with three holes, and to these flanges are riveted two other pieces of boiler steel, ⅛ in. thick, 9¾ in. wide and 16½ in long. When these four parts have been riveted together, a box-like structure has been formed. The top of this box, as shown at *C*, is made of one piece of ⅜ in. boiler steel, 8¼ in. wide and 9¾ in. long. Short pieces of angle iron are riveted to this top *C* and also to the channel iron *A*, and the pieces *B*, of the form. Care must be taken to set these angle irons far enough away from the edge of the cover *C* so that they will fit snugly within the four sides of the iron box. All rivet holes should be countersunk, so that the work may be perfectly smooth after the riveting has been done. The piece *D* is composed of an iron strap 8½ in. long, 2½ in. wide and ⅝ in. thick, turned up 1½ in. at each end. Holes are drilled in the turned up portion, and this is riveted to the lower end of the box.

A hole 1 1/16 in. in diameter is drilled in the center of this strap. The supporting member of the frame is the iron rod *E*, which is 1 in. in diameter. The length of this rod before it is bent is 34 in. The long bend is 19½ in. and the short bend 9 in. Both ends of the rod are threaded for 5 inches before bending. The block *F* is made of one piece of iron 3¼ in. long, 2 in. thick and 2½ in. wide. It contains a hole 1 1/16 in. in diameter *G*, through which the long bend of the rod *E* is passed. In the center of the face of this block is drilled a 19/32 in. hole part way through into which is driven a ⅝ in. stud having a ⅛ in. hole drilled in the end of the stud, into which a ⅛ in. piece of drilled steel has been driven in order to keep the stud from backing out of the block. In one of the lower corners of this block a hole is drilled entirely through for the purpose of inserting a pin in order to hold the block in any desired position. The part *I* is of boiler steel ½ in. thick, 14 in. long and 6 in. wide, previous to bending. It is tapered as shown, having a large hole drilled in the horizontal portion in order to secure it to the work bench, and at the tapered end of the piece is drilled a hole sufficiently large to accommodate the stud *H* of the block *F*, which is secured to the upright portion of *I* by a nut. A series of holes arranged in a semi-circle just below the hole for the stud allows a pin to be inserted through the block *F* and hold the block in any desired position. The portion of the piece *J*, which rests upon the corner of the bench, is an exact counterpart of the horizontal portion of *I*. A part of the piece *J* is bent over at right angles to this horizontal section, so as to hold it firmly against the edge of the bench. A number of holes are arranged in a semi-circular form into which the pin of the part *I* is inserted, thereby permitting the portion *I* to be swung about and held in any particular position desired. The box-like structure is mounted on the small bend of the rod *E* by first screwing down a hexagonal nut and then placing upon it a large washer and finally inserting the short end of this rod into the hole in the strap *D*, and clamping it firmly with another nut. The long bend of the rod *E* is held by two nuts, one above the block *F* and one below. The horizontal and vertical positions of the form in use is shown in the two photographs of Fig. 2.



Two Views of the Form in Use Showing How it May Be Placed in Different Positions

A Blue Print Bath

A solution of one ounce of bichromate of potash to three gallons of water makes an ideal bath in which to wash blue prints, as it will darken the color and fix the chemicals so the prints will not fade. The print must be exposed slightly longer than when clear water is used and it is well to rinse after removing from the bath. The solution can be used indefinitely by replacing the water that evaporates and, when running water is not available, such a bath is necessary.

It is always well to have a bichromate solution handy in any blue print room for use in bringing back over-exposed prints, in which case the best practice is to first wash the print in clear water for a few minutes and then immerse it in the bichromate bath and rinse. Nice clear whites will result.

Ohm's Law Simplified

The two diagrams given below cannot be claimed to be new, but with the changing forces of electrical men as years go by it frequently happens that some of the older things can be repeated with decided advantage to the new men in the field. The diagram illustrates an easy way of remembering Ohm's law, and for figuring current, watts or volts in any d. c. circuit. By simply covering up the unknown quantity, whether it be volts, current, resistance or watts, the other two known factors will give you the answer.

For example, if it is desired to know the voltage drop through a certain resistance where the current is known, by covering the unknown (volts) we find that the answer is current times resistance. If the resistance is unknown and volts and current known, by covering the unknown (R), we find that the answer is volts divided by current, which gives us the resistance of the circuit. If the current is unknown, by covering up (C) we find the answer is volts divided by resistance, which gives us the current of the circuit. Similar with the power diagram if we simply cover the unknown quantity the other two give the answer. If the total watts in the circuit are unknown the current and volts known, we find that by covering watts in the diagram that the answer is current times volts; if we know the total watts and total volts and wish to know the current, by covering (C) in the diagram we find the answer is watts divided by volts. If we know the total watts and current and wish to know the volts we find that by covering volts in the diagram that the answer is watts divided by current.

Diagram for Using Ohm's Law

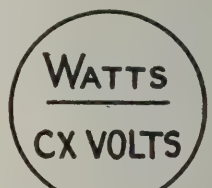


Diagram for Figuring Poor Circuits

NEW DEVICES

New Lamps for Locomotives

The illustration shows one type of new electrically lighted lamps that are manufactured by the Pyle-National Company, Chicago. The lamp shown is cast of a non-corrosive metal, which is claimed to be lighter and tougher than cast iron. It is tapped at the top for continuous conduit and provided with three supporting lugs. The lamp is equipped with a standard white signal lens, 5⅜ in. in diameter. A hinged door forms the bottom of the lamp which, when opened, permits access to the interior, thus permitting lamp renewals and wire connections. The door is securely fastened with a spring latch. A receptacle with lamp grips is used and the connections to the receptacle are made in such a manner as to leave them accessible when testing the lamp circuit. In addition a piece of plate glass covers an opening in the bottom of the case through which a beam of light is thrown downward and outward, lighting the coupler

New Tender Lamp With Bottom Door

and step. The beam of light is augmented by means of mirrors placed inside the case and at a suitable angle to reflect the additional light to the outer portion of the lighted area. The overall dimensions are 8⅞ in. high, 7¾ in. wide by 5 in. deep.

The second illustration represents a portable cast headlight which is used for emergency purposes on tenders of locomotives called into transfer, helper and emergency switching service. It is also manufactured by the Pyle-National Company. It is cast in one piece and tapped at the back for extension connection. A substantial wedge lug is cast on the back by means of which the case is attached to the rear of the locomotive tender. A cast bracket, into which this lug fits, is furnished with the case. The lamp is fitted with a 10 in. lens, which is held in place by a spring ring in a machine groove. The interior of the case is reached through a heavy cast door. A machined taper surface on the door and in the lamp body provides a water-proof joint and excludes the destructive gases from the interior of the case.

The lamp receptacle is arranged so as to bring the

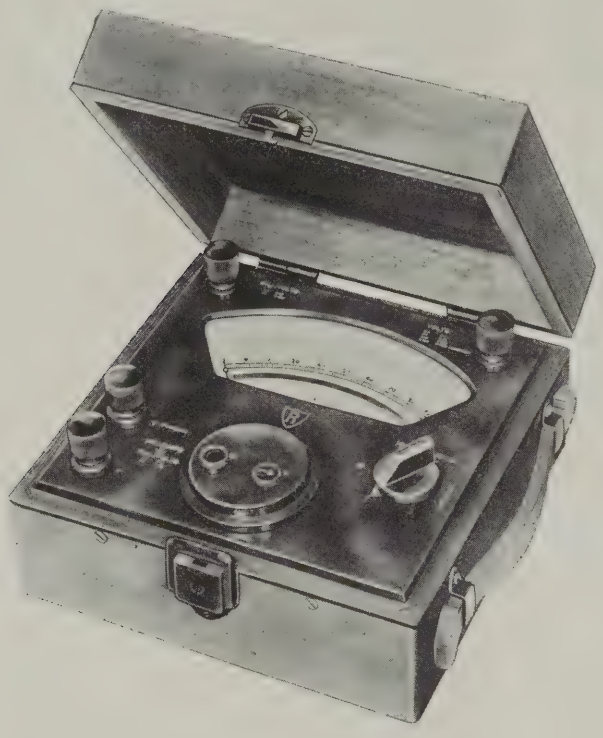
Portable Cast Headlight for Emergency Purposes

lamp filament into the focal point of the lens without adjustment and gives a light beam that will meet headlight vision requirements without the use of a reflector. The case can be furnished in either cast iron or aluminum composition. The cast iron case weighs 29 lb. and the aluminum case 14 lb.

Two Meters for Railroad Service

The Burton-Rogers Company, Boston, Mass., are offering a type of a.c. voltmeter which has recently been developed for railway service, in which a sensitivity of 80 ohms per volt is attained and in which overlapping ranges allow continuous readings from 0.1 volt up to 125 volts to be obtained. This meter is of the single pivot thermal type and is claimed to be accurate on direct and alternating currents of any frequency up to 2,000 cycles. It is further claimed that this instrument embodies characteristics commonly found only in reflecting galvanometers and that it is unusually adapted for general use on account of its immunity from damage while being carried about, as a clamp is provided

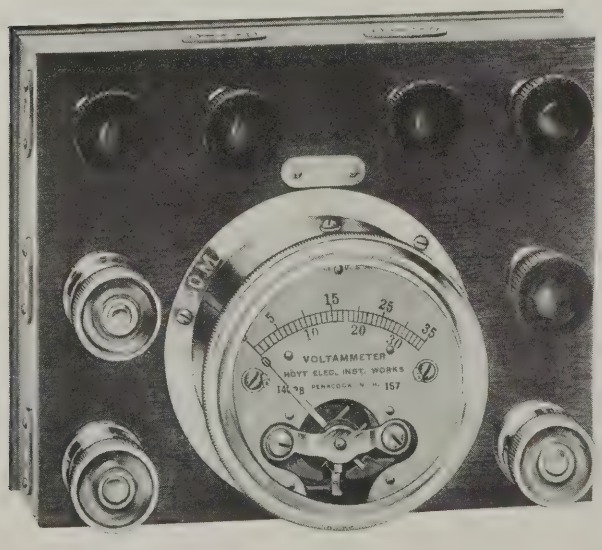
which allows the pivot to be raised from the jewel, at the same time clamping the moving coil securely against the core iron, a method generally used in high grade compasses. These meters are made in two sizes, one with a 5-in. and the other with a 3-in. scale, the



Thermal Type Voltmeter

smaller instrument having a sensitivity of approximately 50 ohms per volt.

A portable measuring instrument known as the Hoyt Rotary meter, type 516, is also being distributed by the Burton-Rogers Company, sole selling agents for



Hoyt Rotary Voltammeter

the entire Hoyt line of electrical instruments. The instrument is 5¼ in. long, 4½ in. wide, and 2⅝ in. high, consisting of a stationary commutator mounted in a suitable receptacle, provisions being made for a number of shunts and resistances, connections with which are made through the several segments of the commutator. A small milli-voltmeter having a sensitivity of 75 ohms per volt is centrally pivoted to the commutator in such a manner that the meter terminal makes connection with successive segments of the commutator as the meter is rotated on its axis. A fixed index finger on the side of the meter case shows the position of this terminal and suitable markers on the surface of the commutator receptacle show the position of the segments. The meter is so designed that no current passes through it unless the index finger points to the marker corresponding with the binding post connected with the source of current, it being claimed that this arrangement lessens the danger of damage by overloading the instrument through the making of a wrong connection.

Special compartments for the necessary coils and shunts each connected with a "Central" make connection at will with the simplest form of indicating instrument. This instrument is provided in five, six or seven ranges.

Meno Rust Remover and Cleanser

A preparation known as Meno rust remover and cleanser has been developed to remove rust from machines, engines, tools, and all metal surfaces, thereby greatly reducing the time and labor previously required for this work. The compound is a blending of certain chemical ingredients, which in combination produce an electro-chemical action that rapidly loosens and dissolves rust, corrosion, grease, oil, dirt, carbon, paint or any other foreign substance adhering to the metal, irrespective of its age or hardness. It is stated that the action automatically ceases when contact between the cleanser and the metal is established, and it will not injure or mar the surface of the metal itself.

The preparation may be applied with a brush or by dipping. It will not burn or explode and protects the metal and makes it exempt from corrosive or disintegrating action for a long period after treatment. The preparation is an economical one to use, as it does not deteriorate or lose its cleansing power and the same solution may be used many times over. Peter A. Frasse & Company, Inc., New York, are the sole distributors, and are now establishing agencies in various parts of the country for the sale of this preparation.

A 100-Lb. Welding Machine

A welding machine weighing complete 100 lb. which is intended with reasonable care to accomplish any work in or around a garage, plumbing shop, etc., has been developed by the Electric Arc Cutting & Welding Company, Newark, N. J. The machine uses electrodes from 1/16 in. to 5/32 in. in diameter and will operate continuously with the medium and small sizes and intermittently on the large size. The standard machine is 110 or 220 volts and any frequency specified. The power supply must be of at least 5 kva.

There has been a need for a small welding machine that was capable of doing the smaller jobs and the new welder will undoubtedly prove popular.

General News Section

Louisville & Nashville.—This company, which will construct a 600-ton coaling station at Loyall, Ky., with company forces, has ordered the automatic coal elevating machinery for this station from the Ogle Construction Company, Chicago.

The Roller-Smith Company, New York City, announces the appointment of the J. E. Dilworth Company, 493 South Main street, Memphis, Tenn., as its representative in the western half of Tennessee, the eastern half of Arkansas and the northern half of Mississippi.

B. A. Bell, railway specialist for the Western Electric Company, has been appointed railway representative of this company in the Atlanta, Ga., office effective February 1, succeeding J. W. Smith. Before taking up the duties of railway specialist Mr. Bell was general salesman for the Western Electric Company.

The Bryant Electric Company announces the appointment of Robert M. Eames as general sales manager to fill the vacancy caused by the resignation of Frank V. Burton. Mr. Eames has been active in the sales organization of the Bryant Electric Company for fifteen years and for the last few years has been its export manager.

The Chilean government is asking for bids, to be opened in April, for the electrification of the government line from Valparaiso to Santiago, according to reports received by the Guaranty Trust Company. Bids are also asked for quantities of rails, switches and track accessories, for use on the government roads in the northern and central parts of the country according to reports.

The National Electric Code has been submitted to the American Engineering Standards Committee by the National Fire Protection Association for approval as an "American Standard." This code is submitted in accordance with the special provision in the procedure of the committee under which important codes in existence prior to 1920 may be approved without going through the regular process followed in new work. The committee is now making an effort to learn of the extent to which the code is used and any other information regarding the code in meeting the needs of the industry.

The B. F. Goodrich Rubber Company, Akron, Ohio, on December 31, 1920, celebrated its golden anniversary. The company was incorporated December 31, 1870, by Dr. Benjamin Franklin Goodrich. In a golden anniversary greeting to employees and customers, President B. G. Work said in part: "We feel a thrill of pride as we look back over the years and realize the part we have played in the development of the rubber industry." The Goodrich company commemorated the golden anniversary by publishing an attractive 48-page book called the Golden Year of Goodrich, telling of the romance of the rubber industry, its history, and of what great importance it has been in the progress and development of the world. The book was written by Wilbur D. Nesbit and illustrated by W. T. Benda, the Polish-American painter.

Super Power System Not to Be Operated by Government

The super power system, which has been proposed to provide power for a large area including Washington, D. C., New York, N. Y. and Boston, Mass., has been described in previous issues of the *Railway Electrical Engineer* and provides for a large interconnected power system to supply both railroads and industrial plants. It was again the subject for discussion at a meeting of the Boston, Mass., Sections of the American Institute of Electrical Engineers and American Society of Mechanical Engineers and the Boston Society of Civil Engineers on January 18. W. Murray, chairman of the survey, said that a return of 10 per cent on the investment would be essential for the success of the enterprise and that the project would be doomed to failure if the yield should be limited to 6 per cent. Construction methods to be used have not been completely decided upon but Mr. Murray stated that a 300,000 kw. steam plant and a super power transmission line from the Hackensack meadows to Philadelphia would now be a paying proposition. He also strongly affirmed the intention of those interested in the scheme to keep clear of the morass of government ownership or operation and said that no money had been sought from the United States Treasury for financing the proposed development. It has not yet been determined whether it will be better to operate through a federal charter or through synchronized state charters. Consideration is being given to transmission of hydro-electric energy from the St. Lawrence River. The report of the survey, which probably will be made in June, will give special attention to the problems of industrial and generating-plant heat balance.

Hydroelectric Development in Portugal

The Portuguese Minister of Commerce has appointed a commission to study the matter of the utilization of the water power of the rivers of Portugal for the purpose of furnishing hydroelectric power for railway, power and lighting purposes.

Two engineers, Senhores Fernando de Souza and Vicente Ribeiro, have been nominated by the representatives of the Portuguese National Railways to sit with this committee, which has been created at this

time to study these matters principally because the outlook for fueling supplies for Portugal, which possesses no working coal mines, is not at all bright, owing principally to the high prices of imported coal and the uncertainties as to available coal supplies in producing countries.

In the case of the Portuguese rivers it would be necessary to construct an extensive and likewise expensive system of dams, with a view to conserving enough of the water from the winter rainfall to last through the summer.

The headwaters of the largest Portuguese river, the Douro, are situated across the frontier in Spanish territory, and for this reason, before any definite plans for the utilization of its power can be formulated, it will be necessary for the Portuguese and Spanish Governments to come to some sort of an agreement for the division and distribution of the Douro water, for as matters stand now it is possible for Spaniards having farms in the basin of the upper Douro to divert practically all of its water for irrigation purposes.

This commission will also be expected to study the question of the utilization of a number of seams of coal which are known to exist in Portugal, and it is even possible that it will study Portugal's petroleum possibilities as well.

Heavy Electric Traction Program for A. E. R. A.

The committee on heavy electric traction of the Engineering Association of the American Electric Railway Association has made preliminary assignments on the subject of heavy electric traction about as follows:

1. Co-operate with the American Railway Engineering Association regarding progress in heavy electric traction with a view to keeping the members of the American Railway Engineering Association posted on developments in the field. In this connection cover foreign practice as well as that in the United States.

Much of the information pertaining to foreign electrification will be obtained from the files of H. W. Cope and from the General Electric Company. Any additional information which is deemed desirable will be obtained by correspondence.

2. Continued compilation of statistics regarding electric locomotives.

Last year's committee issued a number of questionnaires regarding equipment to America's electrified railroads, and to industries operating electric locomotives. The results, however, were not entirely satisfactory, comparatively little information being obtained. In order to attack the subject from a different direction, Mr. Cope will undertake to go over the list of companies which are using Westinghouse equipment and will tabulate information from the engineering files of the Westinghouse Company.

A. H. Armstrong, chairman of electrification committee, General Electric Company, will be requested to compile similar data from the files of the General Electric Company.

It was the consensus of opinion that locomotives and multiple unit car tabulations should be continued. The subject "Locomotives" will include locomotives with four driving axles, and multiple unit cars will include equipment in which the trailers, as well as motor cars, are equipped with controllers for operating from either end. Equipment which does not conform strictly to these limits may be included at the discretion of the traction committee.

3. Continued study of electric switching engines.

Records of electric switching results are scarce as few companies operate electric switches extensively and some data will probably be obtained regarding steam switching and further data selected on electric switching as it becomes available.

4. Study the subject of multiple unit cars vs. electric locomotives in passenger service and report on the percentage of service given by means of such cars.

There are virtually but three railroads in this country which operate both multiple unit and locomotive equipment electrically, and information necessarily will come from these railroads. C. H. Quereau, superintendent electrical equipment, New York Central, will take charge of obtaining and compiling data on this subject.

Training Future Executives

The will to learn is being fittingly demonstrated by the workers of the electrical industry. Nearly 1,500 employees of the Western Electric Company are busy these winter evenings attending the educational courses which are being conducted at the many branches of the company throughout the country. What makes the figures particularly interesting is the fact that attendance at the schools is entirely voluntary.

The records of the classes conducted at the company's big factory near Chicago show an enrollment of 962 employees this term. The courses in telephone practice and mechanical drawing have proved the most attractive; 225 are registered in the former, and 124 in the latter. The other departments in the order of their apparent attractiveness to the plant personnel are practical mathematics, sewing, comptometry, electricity and magnetism, typewriting, English, accounting, production principles and manufacturing principles.

The opportunities for advancement offered in the night schools appeal alike to the factory operative, the engineer, the clerk and the salesman; 332 members of the engineering department of the Western Electric Company are using their spare moments as study periods. They are paying particular attention to the class in machine switching, a subject which has become of vital importance to technical men since the introduction of the automatic telephone into commercial use. Applications for this branch ran so high in numbers that it was necessary to split the class into two parts. The principles of direct and alternating currents, and shop mathematics are also big favorites with the students.

Classes in accounting and the general routine of business are being conducted at the offices of the company at 151 Fifth avenue, New York and at 195 Broadway where 110 representatives from the two metropolitan offices are enrolled in five classes.

The directors of the schools demand constant application. These classes are a part of the company's fixed policy of being always on the look-out for men who show promise in administration, mechanics, or other of the varied fields of endeavor which the company's extended activities embrace.

Personals

H. W. Williams, formerly assistant engineer in the electrical department of the Chicago, Milwaukee & St. Paul, with headquarters at Seattle, has been appointed special representative to the general superintendent of motive power, with headquarters at Chicago.

Frank D. Fagan has been elected vice-president and general manager of the Edison Storage Battery Company, Orange, N. J., and E. M. Cutting, has been appointed assistant to general manager, both with headquarters at Orange.

F. D. Fagan

Mr. Fagan was born in California and was in the electrical business in San Francisco for a number of years. He then served as manager of the lamp department of the General Electric Company on the Pacific coast, with headquarters at San Francisco, Cal., for over 12 years and now becomes vice-president and general manager of the Edison Storage Battery Company.

Mr. Cutting began railway work in 1888, in the signal department of the Southern Pacific. In 1898, he was appointed supervisor of signals for the Western division and in 1902, in addition to his duties in the signal department, he was given charge of electric train lighting. In 1908, he became engineer of train lighting, heating and ventilation, resigning in 1912 to become Pacific coast manager for the Edison Storage Battery Company, with headquarters at San Francisco, Cal. He remained in that position until September, 1919, when he was appointed manager of the railroad department, with office at Orange, N. J., from which position he subsequently resigned, and now returns to the service of the Edison Storage Battery Company as assistant to general manager, as above noted.

E. M. Cutting

A. H. Darker, chief engineer and manager of the electrical department of J. Stone & Co., Ltd., Deptford, England, has returned to London after concluding a business tour round the world occupying some two years and nine months. The Stone-Franklin Company with headquarters at St. Louis, Mo., is the American branch of J. Stone & Co.

A. H. Griswold, formerly plant engineer for the Pacific Telephone & Telegraph Company, with headquarters in San Francisco, has been appointed assistant chief engineer of the International Western Electric Company, Inc., in New York. After his graduation from the University of Illinois in June, 1901, Mr. Griswold entered the engineering department of the Western Electric Company. In 1905 he became affiliated with the Pacific Telephone & Telegraph Company.

S. W. Dudley, widely known authority on matters pertaining to train and traction control, retired on February 1 as chief engineer, of the Westinghouse Air Brake Company, Wilmerding, Pa., to accept a professorship of mechanical engineering at Yale University.

S. W. Dudley

Mr. Dudley has been associated with the air brake company for 17 years. Starting as a special apprentice in 1903, he spent the summer of that year and the next in the plant, returning to school to complete a post-graduate course during the other seasons. When he established permanent connection with the organization in 1905, he was attached to the office of the late Walter V. Turner, then mechanical engineer of the Westinghouse Air Brake Company. Here he was assigned as a member of the party in charge of the first road tests of the Type R triple valve between Pittsburgh and Fairchance, on the Pennsylvania Railroad, later acting as engineer's assistant during a series of important demonstrations of the ET equipment and the Type R passenger triple valve on the New York Central. He was charged with the responsibility of compiling much of the data relating to these demonstrations, which resulted in the development of the high emergency retained features which were added to the Type R triple valve to complete the Type L, which was later adopted for the motor cars of the New York Central's electrified zone.

In 1906, Mr. Dudley was assigned to the New York office to follow the installation, operation and maintenance of new air brake equipment that was placed in service on electric locomotives and motor cars during the inauguration of the New York Central's terminal electrification. A year later he was called back to Wilmerding to take charge of the air brake publicity department, where he remained until 1909, when he was appointed assistant mechanical engineer. In 1910 he became assistant chief engineer (in charge of operation), and in 1914 he was advanced to the posi-

tion of chief engineer, which title he retained up to the time of his resignation.

Mr. Dudley graduated from Yale University, to which he now returns, with the class of 1900, completing thereafter a post-graduate course which qualified him for his M.E. degree.

J. Allan Smith has resigned as president of the U. S. Light & Heat Corporation, Niagara Falls, N. Y. Mr. Smith is leaving to engage in business for himself, a step which he has long been contemplating. He has been identified with the affairs of the U. S. Light & Heat Corporation for a number of years, managing its business during the most precarious times of its existence. In the early days the business of this company largely consisted of the manufacture and sale of train lighting devices. Under the management of Mr. Smith the storage battery manufacturing business has grown until now the company is one of the largest battery producers of this country. Mr. Smith has been succeeded by C. O. Miniger, of Toledo, Ohio, who is vice-president of the Willys Corporation and general manager of the Auto-Lite division of that corporation at Toledo. Mr. Miniger is well known to the automobile industry; he has been closely identified since the very early days of the automobile, with the manufacture and sale of electric lighting and starting devices for motor cars. He was one of the original incorporators and organizers of the old Electric Auto-Lite Company, which began in a very limited way manufacturing electric starting devices. When John N. Willys acquired control of that company, Mr. Miniger was placed in charge of its affairs and through his efforts its business has been built up to one of the largest producers of electric starting and lighting devices for motor cars. It has also become a large producer of farm lighting outfits. Mr. Miniger will give all of the attention which may be necessary to his new duties but will still continue to be in charge of the Electric Auto-Lite Division of the Willys Corporation at Toledo. His title in the U. S. Light & Heat Corporation will be president and general manager. C. L. Lane has resigned as vice-president and general manager of the U. S. Light & Heat Corporation and D. H. Kelly has been elected to serve as vice-president and assistant general manager. Mr. Kelly was for eight years secretary of the Toledo Scale Company, Toledo, and for the past two years has been assistant sales manager of the Willys Light division of the Electric Auto-Lite Corporation. He has had ten years' experience in the railroad field.

Obituary

William H. Sayre, president of the American Abrasive Metals Company, New York, died suddenly at his home in Glen Ridge, N. J., on January 6. He was born at Mauch Chunk, Pa., in 1865, and graduated from Lehigh University as a mechanical engineer in 1886, and since that time has been actively engaged in some line of business in which his engineering ability was applied. He began his practical experience in railroad building in the Northwest. Mr. Sayre later became president of the International Contracting Company, executing many dredging contracts in New York and other harbors, and also served as a consulting engineer on the Cape Cod canal. He was among the first to apply electric welding commercially, having organized the Federal Welding Company, New York, and the Anthracite Electric Welding Company, Wilkes-Barre, Pa. In 1911 he organized the American Abrasive Metals Company of which he was president until the time of his death.

Trade Publications

Space Heaters and their uses are described by an 8-page envelope size folder issued by the Cutler-Hammer Manufacturing Company, Milwaukee, Wis. The title of the folder is "2 Feet of Electrical Heat."

A large double-folded card, issued by the Crouse-Hinds Company, Syracuse, N. Y., describes vapor, gas and waterproof switch covers and suggests a variety of uses for this type of condulet. The title of the folder is "These are what we should use."

Commutating Pole Direct Current Crane and Hoist Motors is the title of Bulletin 48100A, which supersedes Bulletin No. 48100, issued by the General Electric Company, Schenectady, N. Y. This bulletin gives a detailed description of the construction of parts of this class of motor, together with a table of standard ratings, drawings and dimensions.

Every Day You Use An Exide Battery.—The Electric Storage Battery Company, Philadelphia, Pa., has recently issued a 32-page illustrated booklet showing various uses of Exide batteries. The object of the pamphlet is to suggest by means of artists's drawings the more important ways in which Exide batteries serve in industrial and social life.

The Metal & Thermit Corporation, New York, has issued a small book called Thermit Railroad Instruction Book No. 41 expressly prepared for use by men actually performing Thermit welding railroad repairs. The pamphlet is of a convenient pocket size and the instructions have been condensed into the smallest possible space consistent with clearness.

Benjamin-Starett Panel Boards and Cabinets are described and illustrated in catalog S-3 issued by the Benjamin Electric Manufacturing Company, New York, N. Y. The slogan "For every lighting requirement" briefly expresses the purpose of the standardized panel boards described in the catalog. A pictorial index is provided for quick reference and shows clearly, in condensed form, the specific purpose of the various types of panels described.

The Electric Division of the Chicago, Milwaukee & St. Paul Railway is the title of an attractive 42-page bound booklet published by the General Electric Company, Schenectady, N. Y. This booklet is issued as Bulletin No. 44013A, superseding 44013. It describes the topography of the Rocky Mountains, Missoula, Coast and Columbia electrified divisions and gives a short history of the electric operation, describing the development of regeneration. The technical elements are also described, including the electrical equipment, motive power, the passenger, freight and switching locomotives, the sub-stations, the circuit breaker protection, the power limiting and indicating system, power supply and the overhead construction.

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Where Is the Spirit of Loyalty

Not long ago when labor was short on the railroads, as it was everywhere else, the fact that a man was not enthusiastic over his work did not excite any particular comment. Inefficiency in practically every industry was so common a thing that really ambitious men were few and hard to find. This state of affairs must be recognized as the outgrowth of the conditions that obtained during the war and as such some reason may be found for its existence during that trying period. There is, however, no good reason why it should continue to sap the resources of the railroads. There are today still too many men who are totally indifferent to the welfare of the company that employs them.

Many of the better class of railroad employees have the wisdom to see the necessity for an honest day's work, but there is still too large a number of the other type whose sole interest centers on the pay car. They help to increase the payroll and they help to reduce efficiency. Moreover, their very presence radiates a spirit of discontent and disrupts the morale of the men who naturally would be loyal. One of two things should be done with these non-producers—either by discipline or other means make them render service for the wages paid them, or discharge them. It is these men who are constantly undermining the morale of the better class of skilled workmen. The unfortunate part of the situation is that the high grade employees are actually supporting these idlers, but do not appear to realize the fact.

An Automatic-Electric Subway

A plan for reorganizing the freight-handling facilities in the Port of New York has been proposed by the New York-New Jersey Port and Harbor Development Commission. It involves a special automatic-electric subway system which would transport freight from a union freight terminal in New Jersey over a loop railroad to various points on Manhattan Island, where lifts would raise the special cars used to the street level for unloading and loading. It is described elsewhere in this issue.

In an address before the New York Railroad Club on February 18, J. J. Mantell, manager of the New York region of the Erie, left little doubt in the minds of his listeners that he was very much opposed to the program as outlined by the commission. Mr. Mantell was in charge of the railroad terminals in the New York terminal district for the Railroad Administration, and can be regarded as a good authority on conditions in that city. He expressed the opinion that the proposals of the commission were impracticable and would not warrant the expense, and suggested the use of specially arranged motor truck bodies or detachable containers similar to those used at Cincinnati for interchange l.c.l. freight.

Regardless of what methods are employed to accomplish the result, the fact remains that the Port of New York is in need of reorganization and the need is probably great enough to cause action in the near future. Public opinion in the vicinity is demanding it. At present it is difficult to finance a large project, such as suggested by the commission, and this very fact strengthens the position taken by Mr. Mantell. A system such as used in Cincinnati can be applied with comparatively few changes and the changes can be made quickly, but particularly in New York and vicinity it would mean that the traffic would be kept on or added to the traffic on already congested streets. In any event, much electrical equipment will be necessary in the form of trucks, tractors, conveyors, elevators and perhaps railroads. The electrical, material handling and transportation engineers have a problem which must be solved quickly. Some program should be adopted so that users of equipment can purchase new equipment, which will later fit in with a general scheme.

A New Department

Readers of the *Railway Electrical Engineer* who have long been accustomed to scan carefully that section of the paper devoted to practical stunts will note that this month the old heading has disappeared and a new one has taken its place. With this issue the new department known as *The Interchange* makes its first appearance.

For some time it has been felt that the Practical Stunts column did not entirely meet the requirements as well as it might and that more interest could be awakened if this department should broaden its scope so as to include a greater diversity of ideas and material. Inasmuch as such a changed policy would necessarily mean the inclusion of other subjects than those which could be classified as strictly practical stunts the new title of *Interchange* was chosen. Under the new head practical stunts will be published as heretofore. The name *Interchange* is to be interpreted in its broadest sense and space will always be available in this department for the interchange of ideas among our readers regardless of

whether or not these ideas can be considered as practical stunts. In addition there will be short human interest notes in a lighter vein on railroads and other related topics.

Finally, although by no means of least importance, will be that portion of the interchange devoted to the solution of various electrical problems. This section will be designated as "The Question Corner," and it is hoped that the reader will use it to the fullest extent. Questions pertaining to electrical problems will be published each month, the correct solutions being published the following month. We should like to have our readers send in solutions to the problems which appear, their solutions to be published in each case in the issue immediately following the appearance of the problem. The question corner can be made of greatest benefit to men seeking information on specific problems and it is hoped that they will not hesitate to use it to the utmost.

Superpower Survey

The Progress Report of the superpower survey which appears on page 117 of this issue is particularly interesting in view of the explicit figures and statistics given. The facts presented show conclusively that the territory affected by the plan will ultimately require the entire output of the proposed power system. The kilowatt hour demand within this section is bound to increase and any steps that can be taken that will aid in the generation of cheaper power should be encouraged in every possible way. There has been a feeling more or less prevalent that the superpower plan was visionary. The truth of the matter is that the scheme is of such great magnitude and such a radical departure from the well beaten paths of present practice that the majority of "doubting Thomases" are unable to grasp the vast economical importance of so great a project. Fortunately, there are enough men whose breadth of vision is not circumscribed by the activities of the present and who are capable of looking ahead to the requirements of the future. These men have placed their ok. on the project and this portends its ultimate success. There will unquestionably be financial difficulties in the way of a development so large, but the eventual demand for power will be more than sufficient to overcome this. W. S. Murray, who is in charge of the survey, recently stated that to insure the financial success of the plan, it would be necessary for the project to earn at least 10 per cent on the investment. John Barton Payne, ex-Secretary of the Interior, is of the opinion that considerably greater saving than that could be effected. He states that one third of the mileage of class I railroads in the superpower territory can be economically electrified at a cost of approximately $800,000,000 which with salvage would be reduced to $650,000,000. It is estimated that the cost of electrifying a mile of road in this territory would be approximately equal to $40,000. These figures are of course estimates based upon information at hand and it is quite possible that they may be at variance with the costs when the work is finally accomplished. As these figures are only estimates it is just as reasonable to assume that the work could be performed for smaller amounts than it is to assume that the sums quoted represent the minimum cost.

In any event, whether or not the plan is successfully carried through at present, there can be no possible question but that the demands of the future will make its installation absolutely imperative.

New Books

The Standard Electrical Dictionary. By T. O'Conor Sloane with additions by A. E. Watson. Published by the Norman W. Henley Publishing Company, 2 West 45th street, New York. 767 pages, illustrated, 5 in. by 7 in., bound in cloth.

Since its appearance in 1892, this work has passed through many editions and found favor as an encyclopedia dictionary of the subject. The present edition has been revised and enlarged by the addition of a second part, 185 pages long, containing the terms, appliances and theories of modern times. Cuts and diagrams are used to elucidate the text.

The Welding Encyclopedia. Compiled and edited by L. B. MacKenzie and H. S. Card, editors of the Welding Engineer. 336 pages, 6 in. by 9 in., illustrated. Bound in cloth. Published by the Welding Engineer Publishing Company, 608 South Dearborn Street, Chicago.

The development of fusion welding processes and the rapid extension of their application in industry during the past decade has created a field which is now becoming highly specialized. Although several books have been published dealing with various phases of welding, the greater part of the literature on the subject is not available to the practical welder, for the reason that it is widely scattered through periodical publications dealing primarily with other matters. The Welding Encyclopedia brings together in one volume a wide range of knowledge concerning welding practice, equipment and auxiliary appliances for all classes of work. About one-third of the subject matter is an illustrated definition section in which all words, terms and trade names used in the welding trade are defined. Short treatises are included in this section on a number of the more important topics, and it also serves as an index to the subject matter in the special chapters on the oxy-acetylene, electric arc, electric resistance and Thermit processes, the use and care of equipment, boiler welding, and the heat treatment of steels, which follow the definition section. A valuable feature of the book is the section on Rules and Regulations, which contains a compilation of the various codes of rules applying to fusion welding. These include the A. S. M. E. boiler code, the regulations of the Department of Commerce Steamboat Inspection Service, Lloyd's Register of Shipping, the Underwriters' Laboratory, the National Board of Fire Underwriters, the American Railway Association (M. C. B.), and the Interstate Commerce Commission specifications for gas shipping containers. The status of welding regulations in the various states is briefly summarized, and where specific regulations have been developed these are given. There is also a catalogue section in which are described equipment, materials and supplies sold commercially for use in welding. The book forms a valuable reference work from which the practical welder may obtain much fundamental knowledge of correct practices for a wide range of work, and to which the general reader may refer for the meaning of terms and for a knowledge of the status of the different branches of the art.

The Montana Canyon as Seen from a St. Paul Observation Car

The Use of Helpers in Electric Train Operation

Helper Cut in 100 Tons Ahead of Middle and Operated for Braking Over Summit and Down Grade

By W. S. H. Hamilton
Railway Equipment Department, General Electric Company

OPERATING with helpers is the common method for handling freight trains. The practice on the Chicago, Milwaukee and St. Paul was to put the helper (where only one was used) at the rear of the train just ahead of the caboose. The helper could thus be easily cut off to take water, and could be readily cut in to the train at the start and cut off the train at the summit of the grade. This method leaves one or two cars in the train, at the location where the drawbar stress changes from pulling to pushing, which are very nearly free and can change the slack either way easily. This causes trouble in handling and may be termed "floating slack."

It was also the practice with steam power to run helpers from the bottom of each grade to the summit; there they were cut off, turned, and then returned to their original stations, only occasionally being run clear over the hill.

Electric operation was started on much the same basis. The helpers were put at the rear of the trains while ascending the grades but were cut off at the summit and run around to the head-end of the train. There the two locomotives were connected in multiple unit and were used to control the operation down-grade.

This method of operation was tried for a month or so but the results were not entirely satisfactory. Signaling between locomotives was difficult because the trains were longer and the whistles on the locomotives were not as powerful as those on the steam locomotives. The road (leading) locomotive could not slack the entire train, which was necessary in case the helper was not ready to start and, when stopping, the engineer on the helper did not always realize it promptly. This resulted in drawbars being damaged to such an extent that they were pulled out when starting again. Much of this trouble came from the "floating slack" near the middle of the train referred to above, and also because electric locomotives do not slow down as much with the application of load as do steam engines.

How Helpers Are Now Used

The method was then tried of cutting the helper into the train about 100 tons ahead of the middle. This insures the slack being stretched out on all cars and makes starting easier because each locomotive handles practically its own tonnage. Also it was found practicable to keep the helper locomotive in the train while descending and allowing it to regenerate to assist in holding the train. This method of operation proved successful and has been used ever since.

The helpers all operate out of one station and normally run clear over the hill, returning with the next train in the opposite direction. Occasionally it is necessary on account of traffic movement to cut the helper out at the summit and let the road locomotive take the entire train down the grade. At such times both regeneration and air brakes have to be used in combination as previously described. Operating the helpers out of one station reduced the number of crews and locomotives required.

When ready to start on an ascending mountain grade

*This is the third of a series of articles on this subject. The first dealt with passenger service requirement and passenger train operation. The second dealt with general requirements for freight train operation. The author acted as an instructor to enginemen on the locomotives used on the C. M. & St. P., from December, 1915, to August, 1917, and from December, 1919, to April, 1920.

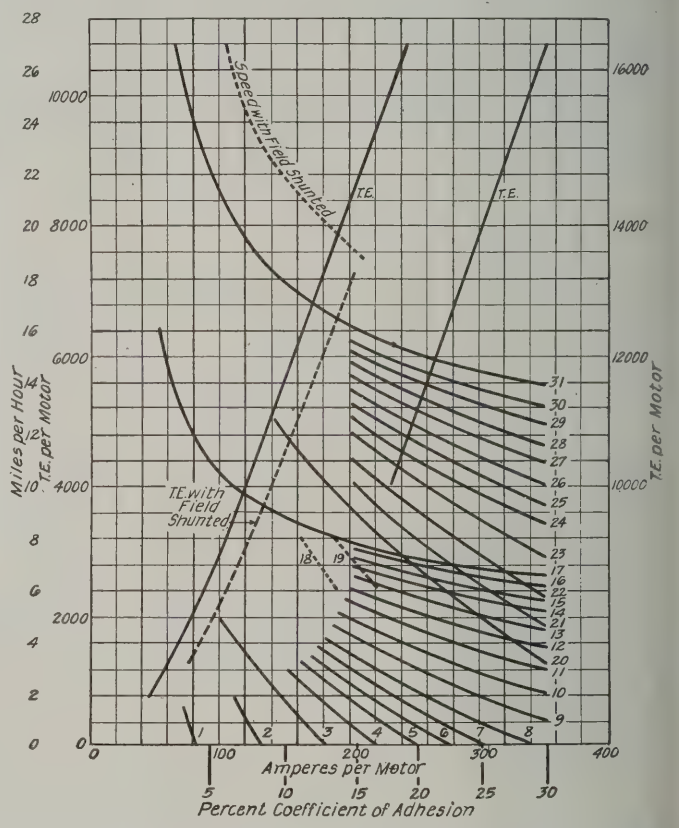
with a helper in the train, the train brakes are released and the train is held by the independent brakes on the two locomotives. The engineer on the road locomotive "whistles off" and the engineer on the helper locomotive answers if he is ready. These whistles are not always heard, however. When the engineer on the road locomotive hears the helper "whistle off" or after waiting a reasonable length of time, he brings the controller onto the first or second notch and releases the independent brakes. This keeps the locomotive from rolling back against the train and as soon as the brakes release the controller is moved out slowly until the train starts, or until the current is as near the wheel slipping point as it is advisable to go. This stretches all the slack in the train as far back as the helper locomotive. The engineer on the helper locomotive watches the drawbar of the car forward of his locomotive and as soon as this stretches out brings his controller onto the first or second notch and releases the independent brakes on the locomotive. As soon as they have released he notches the controller out slowly and carefully until the train starts, or until his locomotive has reached as close to the wheel slipping point as it is desirable to go. After the train has started both engineers watch their ammeters and accelerate as close to the wheel slipping point as desirable until they have reached the full parallel position of the controller.

If, however, the train does not start in what the engineer on the road locomotive considers a reasonable time he notches back his controller slowly and allows the train to drop back gradually against the helper locomotive. This is a signal to the helper locomotive to be ready to start and as soon as the engineer on the road locomotive feels the jolt of the train bunching against the helper locomotive he again attempts to start as before. In cases where several attempts are made to start, this "rolling back" operation is usually repeated with increasing severity each time so that the engineer on the helper locomotive will have no doubt as to what is required. When the latter sees the train dropping back against him as shown by the drawbar of the car ahead, he brings the controller on the first or second notch and releases the independent brakes so as to be ready to start when the leading locomotive again pulls the slack out of the train ahead.

In stopping the train, the engineer on the road locomotive notches his controller off slowly. This becomes apparent on the helper locomotive by the ammeters indicating a higher value of current and the helper locomotive engineer noticing this, notches back his controller to hold a slightly lower value of current than was required by the train while running. This process is continued until the train comes to rest when he applies the independent brakes and shuts off the controller. The engineer on the road locomotive does the same and sometimes applies the automatic air brakes to assist in stopping. This process of stopping requires as much or more care than starting and the control must be designed to give the proper steps both when turning off as well as when turning on.

It is really surprising how much information can be obtained from the ammeter on the helper locomotive and from the action of the drawbar of the car ahead. With a little experience and a reasonable knowledge of the profile so as to know where slowdowns may be expected it is possible to tell practically everything that the engineer on the road locomotive is doing.

When descending a grade the helper locomotive also regenerates to assist in holding the train. If the start down the grade is made at the summit and the train has to be pulled in order to start it, the helper locomotive engineer commences regeneration when he notices the drawbar on the car ahead shove in. If the start is made from rest on the descending grade he commences regeneration when the first airbrake application is made at the same time as the road locomotive. The helper locomotive is only supposed to regenerate enough so that the road locomotive can readily control the train speed. This means that about 30 to 40 per cent of the load is taken by the helper and 60 to 70 per cent by the road locomotive. In case the helper does not regenerate enough the engineer on the road locomotive makes an application of



Speed-Tractive Effort Curves on Resistance for the Electric Freight Locomotives Used on the C. M. & St. P.

the airbrakes and releases soon afterwards. The helper locomotive engineer notices this and knows it is a signal to increase the amount of regeneration.

When stopping, the road locomotive engineer makes an application of the automatic brakes and then shuts off his controller when the line current has dropped to about zero. The engineer on the helper locomotive does likewise and both allow their driver brakes to apply. After the train has stopped, the brakes are released on the helper locomotive and the train is held by the independent brakes on the leading locomotive only.

At the bottom of the grade the helper locomotive is cut out. The brake pipe pressure is also dropped from 90 lb. which is carried on mountain grades to 70 lb. A wise engineer applies and releases the brakes on the train twice, making heavy applications each time before starting as otherwise the brakes will stick due to what is virtually an overcharged brake pipe.

Cold Weather May Cause Many Difficulities

The operation of starting on a mountain grade is fairly easy in good weather but in cold winter weather after the train has been standing an hour or so and the oil has congealed in the journal boxes it is no easy matter. Care must be taken not to apply so much power that a drawbar will be pulled out of some car weaker than the others; this danger is always present in merchandise trains. One is often between "the devil and the deep sea," for if enough power is applied to really get the train going in good shape a drawbar or "lung" may come out; if less power is applied the train accelerates slowly and there is the possibility of not being able to accelerate to a running position of the controller before the rheostats overheat.

The friction after the train has been running for an hour or so is about the same as it is in warmer weather but it is very high when starting. Then too there is usually more or less ice and snow on the track which makes the locomotives slip their wheels easily and requires good sanding of the track and careful watching by the engineer. It is possible by notching back a couple of notches to catch wheels that have just started to slip but once they are allowed to spin it is necessary to shut off and start over again. Wheel slipping, especially if it occurs suddenly on mountain grades, is dangerous in that the sudden shifting of load which takes place between the two locomotives is liable to pull out or push in a drawbar. Wheel slipping can usually be detected before it becomes serious by the "fluttering" of the ammeter needle and when this occurs an application of sand must be made promptly. This "fluttering" is noticeable whether the ammeter is in the circuit of the particular motor which is slipping or not.

The airbrakes give a great deal of trouble in weather colder than 10 deg. F. The hoses freeze stiff, usually when the train is standing more or less bunched; when it is stretched out again they leak badly or open up entirely. This often causes the brakes to stick and their action is uncertain at best. When the brake pipe is leaky the feed valve chatters because of the large volume of air passing through it and this is not only very disagreeable to one who has to listen to it continuously but the valve usually manages to freeze up in time and must be thawed out. Sometimes it freezes shut, in which case the brakes apply at once due to the leaks in the brake pipe; sometimes it freezes open and admits main reservoir pressure to the brake pipe. This means that the brakes will stick after it has been thawed because of the brake pipe being overcharged. In such cases it is best to attempt to keep the train moving, although it is sometimes necessary to shut the controller off in case the additional load due to the brakes dragging causes the current to go too high.

When an application of the automatic airbrakes is made on a long train, there is first a high pitched whistle which is caused by the air exhausting from the equalizing reservoir and this is followed, in maybe a second or less, by the deep roar of the air exhausting from the brake pipe itself. With a very leaky brake pipe the leaks may draw down the pressure faster than the equalizing valve in the brake valve can. In such cases only the first high pitched whistle is heard. This usually means a damaged drawbar before the train is stopped as in such cases the brakes apply hardest at the rear of the train and the train is stretched out. To counteract this an effort is made to draw down the brake pipe pressure faster at the brake valve by making as heavy an application as possible without actually going into emergency.

Train Slack

Train slack is very peculiar and in a long train seems to give trouble in three sections; the head, middle and rear. The cars in these sections seem to run closely bunched together with considerable slack between the sections and this more or less free slack is always ready to start trouble. This is especially the case on lighter grades or nearly level stretches. There was a certain station on the C. M. & St. P. where there was a sag in the track with about 2,000 ft. of not over .4 per cent grade on each side of the sag. When running through this sag the controller had to be moved back to series in order to prevent too high a speed being attained, but still power was being applied to the train. Twice while the writer was instructing on this particular section of the road trains broke-in-two near the middle while passing through the sag. Apparently the rear end speeded up enough to overtake the head or middle portion and some cars came together enough to either uncouple, or else when the train stretched out again as it started to ascend the grade there was enough of a shock to pull out a drawbar or break a knuckle. These two cases happened within a short time of each other and give some idea of the unforeseen and unavoidable incidents which happen in freight train handling.

There was a certain canyon on the St. Paul where there were many curves on about an .8 to 1 per cent grade—just enough so that the train had to be held back a little at times when descending and yet not enough to require heavy applications of the airbrakes. Application less than 8 to 10 lb. usually mean that the brakes will stick more or less after releasing so that with steam locomotives more or less trouble was experienced in taking trains through. With the electric locomotives regeneration is used instead and the need of the light applications is eliminated and operation is thus made easier.

Locomotive Design

To meet the conditions of train handling, as outlined above, successfully the control equipment of the locomotives must be carefully designed so that sufficient rheostat steps and ample rheostat capacity will be provided. The acceleration curves on resistance of the C. M. & St. P. freight locomotives are shown on the chart. It will be noted that the change in tractive effort between notches when accelerating to a maximum of 25 per cent coefficient of adhesion is about 21,000 lb. for the total of 8 motors on a locomotive. The rheostats are designed to allow an acceleration at an average value of 210 amp. corresponding to about 16 per cent coefficient of adhesion for 25 minutes and 300 amp. corresponding to 25 per cent for 15 minutes. These capacities have proven ample in service but are not too large for winter work. It will be noted, too, in examining the curves that the steps are close together from the fourth notch to the eighth, inclusive, and are then spread out more. This provides steps close together at the most critical time in starting a heavy train. The increments in tractive effort between steps have always been satisfactory so that it may be assumed that the proper increment to use with this size locomotive

is about 20,000 lb. to 25,000 lb. per step after the train is in motion.

The field shunting position gives about 50 per cent shunting which is about the maximum which can be used on account of the commutation of the motors.

It is necessary that the traction motors be so designed that they can have currents up to 20 to 25 per cent coefficient of adhesion applied for about five minutes with the locomotive stationary without injury to the commutator. This is often required in starting heavy trains. No trouble from this cause was ever experienced on the C. M. & St. P. locomotives.

Direct current locomotives using series motors for freight service have a great advantage as far as this work is concerned in that the tractive effort developed depends only on the current input and does not vary with the voltage. Therefore, variations in voltage do not affect the ability to pull the train or the current input but simply change the speed. There is some increase of heating due to slower speed of the blowers but this can be neglected for short periods. In case of reduction of voltage for any reason the trains can still be kept moving. The auxiliaries were designed to operate at a minimum of one-half normal voltage (1,500 volts) and some will operate as low as 1,000 volts, although at this voltage the air compressors will not pump up a long train. This feature is also made use of by the power limiting system which was described in the April 9, 1920, issue of the Railway Age.

They also have an advantage in that the speed during regeneration can be varied over quite a wide range especially if the train weight is below the maximum. This allows the lighter trains to make faster time and helps in getting trains over the road. When operating full tonnage trains on the mountain grades, practically only one speed is available ascending or descending, but there are usually stretches of lighter grades or nearly level track between mountain grade sections where it is desirable to use higher speeds.

Freight service in mountain railroading is far more fascinating than passenger service although, of course, it involves much longer and harder hours. It requires at times the greatest skill, patience and resourcefulness on the part of the engineer, and this is not always appreciated by those who have not followed the work on the road, particularly in winter.

The writer would like to express his thanks to the engineers and others on the C. M. & St. P. with whom he was associated, particularly in the early days of the electrification, who worked out many of the methods described in this article and who also showed him many practical "kinks" in train handling that in considerable measure made the writing of this article possible.

Edison Medal Awarded to Prof. Pupin

On February 25, the American Institute of Electrical Engineers awarded the Edison medal to Professor Michael Idvorsky Pupin, of Columbia University, for work in mathematical physics and its application to the electrical transmission of intelligence. Prof. Pupin has done a great deal in the art of communication and in both wire and wireless work his discoveries have been of utmost importance. His work in the development of the loading coil made possible the long distance telephony of the present day. His early experiments with electrical resonance resulted in the perfecting of apparatus for selective receiving of signals in connection with radio work. During the war Prof. Pupin served on several war work committees, one of which, with headquarters at New London, Conn., developed a method of determining the exact location of submarines at rest.

A morality that is based upon prejudices defeats its own ends, because morality that is not based upon sound human and universal principles can not be considered as morality at all.

Photo by International

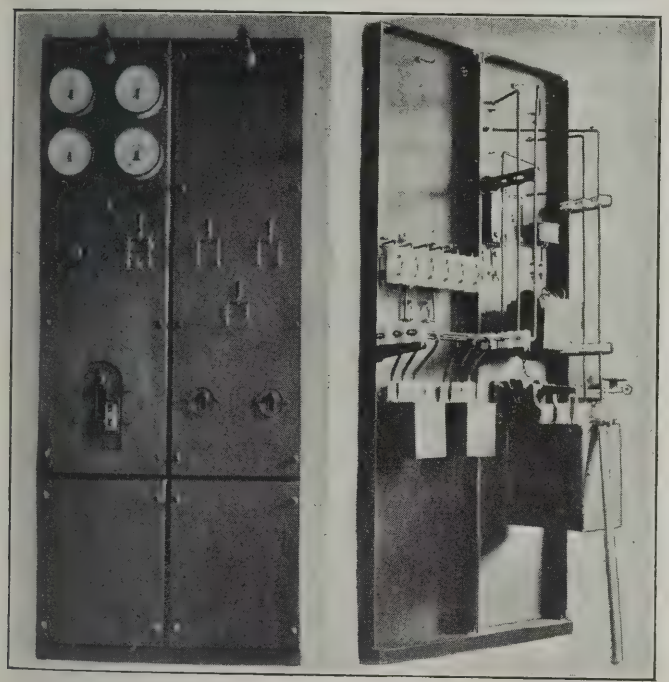
The Railroad Labor Board—Seated to Right: H. T. Hunt, J. J. Forrester, R. M. Barton, W. L. Park, A. O. Wharton. Standing: A. Phillips, L. G. Brooks, H. Baker, G. W. W. Hanger

Lighting Facilities for Small Railroad Towns

An Outline of a Plan Which Is Sure to Be Popular and of Mutual Benefit to Both Road and Town

By Alfred C. Turtle

A RAILROAD is usually conceived in the brains of financiers for the purpose of deriving income from investment in it and, as shown in the history of these ventures at different periods, there has seldom been disappointment. While the idea of eventual gain has been the driving power behind these enterprises, greater and far-reaching demands in the way of agricultural, mining and industrial enterprises have served to develop the railroads at a much faster rate than has been expected by the original planners of such prospects. This has meant that a railroad, instead of being merely an instrument to benefit a few, has become a master institution, benefiting the country in colonizing and building up localities that would be comparatively uninhabited otherwise.



Front and Rear Views of Typical Standard Switchboard Used On the Grand Trunk Pacific. The Watthour Meter for the Town Line will be Placed on the Upper Part of the Right Hand Panel (Front View).

The relation that a railroad may have to small townships that are located at its divisional points is such that the following suggestions are within logical accomplishment:

Real estate operations have, to a large extent, played their part in the layout of the residences in these small towns, and the consequent result has been that they are scattered about with wide open spaces between houses, and in such a way that it has been almost impossible to run distribution systems for electric energy, drainage systems or domestic water supply systems on a proper economic basis. The consequence is that there are a large number of small electric lighting plants that can never hope to pay other than operating and repair charges, at least not within ten years, and, therefore, the interest on the capital invested will remain unpaid, resulting in so much dead loss and tied up money. This cannot be blamed altogether on the real estate activities, because, in a large number of cases, the engineering end of the proposition has been handled by men who have only made a half-hearted study of local conditions; in some cases, where they have not made the necessary study of the financial end of engineering to warrant their standing as professional engineers or to warrant their designing these plants. In other instances, the engineer's idea was to put something up, closely alining the idea of the old Roman bridge builders—to put a plant in that would stand for one hundred years as it was, but could only take care of immediate demands, so that if the demands were increased fifty per cent a new power house would have to be built to contain the additional generators and a new distribution system would have to be installed to carry the load.

In some cases "garden city" ideas have been applied with disastrous results in the way of good street lighting. In one case the distribution system was laid out so that there would be no poles or wires on the main street. In order to do this the town (approximately 1,000 inhabitants) was fed by two main feeders located three-quarters of a mile away, and parallel with the main street. Each transformer secondary system was brought down at right angles, to the rear of stores along the main street frontage and along the back lanes. The consequence of this design was that an excessive amount of copper was required to keep the voltage drop reasonably constant throughout and that the installation of a single street light would cost around eighty to ninety dollars, owing to the necessity for putting in two or more poles in order to reach the sidewalk. Under these conditions an initial expense, instead of being $10,000 for the distribution system, required an expenditure of $25,000. In another case the designing engineer located the generating plant at the extreme distance from the railroad and installed a steam plant to run a 50-kilowatt generating system. It was located where coal cost a maximum figure and where heavy trucking charges would be involved. The operating costs therefore made it necessary that very high rates would have to be charged per kilowatt hour before even considering the question of depreciation or interest.

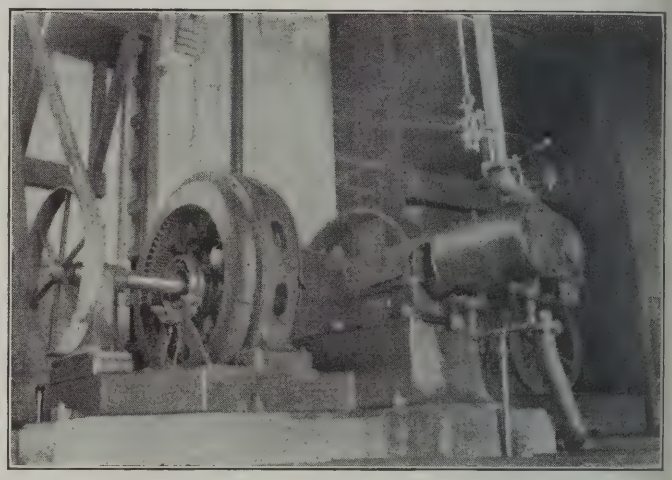
Still another example may be quoted where the engineer's interest ran in the direction of storage batteries. The result of this was that a certain rapidly growing town of 2,500 inhabitants had the pleasure of paying for a direct current, storage battery system that held wonderful possibilities in it, in saving night labor (batteries charged during the day and part of the peak load period)

but which also had a remarkable line voltage variation at different points on account of the lack of large copper conductors that it required. The town was also up against the fact that the designer had forgotten to advise how often the storage batteries would have to be repaired and replaced. The reader will no doubt have the idea running through his mind that such a plant in a growing town would probably be sold for scrap at a later date, and in this he is not far wrong. Imagine the loss entailed to a town operating with such a system with its incapacity for extending on anything that could be called an economic basis.

If one were to go over the different histories and note the different types of plants existing on this continent of ours he would come to the conclusion that inasfar as small towns were concerned coal burning steam plants were the correct things to install in the middle of an oil country where coal was prohibitive and that the reverse should rule where the towns were close to coal mines and oil was prohibitive in cost. It is not the purpose here to decry these attempts to progress, but to point out and offer constructive criticism that would be of value to our coming and present engineers, and for this purpose it is proposed that the following suggestion will be of general use:

A divisional point on any railroad is usually composed of a roundhouse with its quota of engine stalls, auxiliaries, power repair department and switching track. The roundhouse auxiliaries usually consist of a washout plant in which water is heated to a certain desired temperature for washing out locomotive boilers and for filling these same boilers with clean hot water at a temperature as near 212 deg. F. as possible. Anyone acquainted with the desirability of the speedy despatching of locomotives that is required in these days of efficiency first and the amount of washing out that is required in the bad water districts will appreciate the importance of having lots of extra steam or steam at very low pressure. There is installed as part of the roundhouse equipment a battery of boilers which provides the steam for the plant for blowing fires up on the locomotives, for operating the usual air compressors, electric generating equipment, hump and machine shop engines, and, in addition in winter, the heating of the roundhouse, the various shops and offices, in some cases even extending this heating to station buildings. A complete staff of stationary engineers, firemen and laborers must be carried for taking care of the boilers and stationary plants in almost every case. The operation of the various engine units requires steam at pressure ranging from 90 to 200 lb., depending upon the standards used by each particular road, but the heating system and wash-out heating plant does not require anything but exhaust steam and the consequent vacuum pumps. This combination means that steam can be used on a very economical basis in the prime movers, providing the capacity of these prime movers bears a reasonable and fixed proportion to the size of water heating plant installed.

Most of our readers will appreciate how comparatively little heat is lost in reducing steam from 125 lb. gage pressure to 2 lb. above atmosphere or 2 lb. gage pressure. For instance, the steam table would give this value as the difference between 1 lb. of steam at 125 lb., or a total of 1,187 b. t. u. and 1 lb. at 2 lb. pressure containing 1,148 b. t. u., equalling an actual heating loss of 39 b. t. u. Those who use feed water heaters or similar heat conserving devices will appreciate the value of this, particularly from the fact that 1 lb. of this steam at 2 lb. pressure would heat 8.17 lb. of water from 80 deg. to 200 deg. F. In a roundhouse plant where hot water is of first importance and where steam pressure of at least 90 lb. must be maintained for operating the necessary auxiliaries, it would seem that this would be an important item. It follows that the actual fuel cost of operating these auxiliaries which take the steam at high pressure



A 50-Kw. Engine Generator Set With Belted Exciter

and return it to the water heater or wash-out plant, would be very low.

Estimation of Costs

Assuming the foregoing conditions, at the average division point it could be stated that costs would be figured as follows for the generation of electric energy:

Usual Equipment, 18-*Stall Roundhouse.*

3—150 hp. return tubular boilers.
Wash-out plant to take care 20 despatches a day.
Air compressor, 1,000 cu. ft. capacity.
Pumps.
Shop stationary engines, 125 hp.
Heating plant.
100-kw. generator, 3 phase, 2,300 volt, direct connected to automatic compound non-condensing engines.

Fuel at $7 per ton of 2,000 lb.

Water rate of boilers 6 lb. from and at 212 deg. F. per lb. of coal; this rate is an average struck from 18 divisional boiler plant tests.

Water rate of engine (new) at ¾ load per hp. hour would be approximately 27 lb. steam at 125 lb. pressure, or for average conditions increase by 25 per cent, making the water rate 34 lb.

Allow 20 per cent increase for electric generator losses; this would mean a total water rate of 54.6 lb. steam per kw. hr.

Fuel Cost direct would be

Approximately 3 cents per kw. hr., but because 80 per cent of the heating value of the exhaust steam would be utilized in the wash-out plant we could only charge 1/5 of this figure, or .6 cent per kw. hr. as fuel cost.

To the Above Figure Must Be Added

(a) Fixed charges.
(b) Labor.
(c) Overhead.
(d) Waste, Lubrication and Repairs.

These would have to be figured on a monthly basis.

Fixed Charges should be a proportion of the boiler requirements and the complete capitalization required to install the engine generator and switchboard.

A nominal figure of $20,000 would be reasonable for this, assuming the use of a 100 kw. set.

12 per cent would be composed of 6 per cent interest, 1 per cent insurance and 5 per cent depreciation.

This would amount to a monthly charge of.. $200.00

Labor.

On a plant of this kind hand firing would most likely be used, therefore the following staff would be required:

3 laborers at $120 x 3 = ...	$360
3 firemen at $156 x 3 = ...	468
2 staty. engrs. at $160 x 2 = ...	320
	$1,148

20 per cent of this would be a high rate to charge the electric plant with, but, for purpose of comparison, this figure will be used.

Therefore, cost of labor, per month..... $229.60

Overhead Charges may vary considerably, but, as an average, 80 per cent of the labor cost could be defined as a reasonable rate.

This would be monthly..... $183.68

Waste, Lubrication and Repairs at .0025 cent per kw. hr. at a monthly consumption of 55.500 kw. hr. would be..... $138.75

Load Conditions—Monthly Average

Lighting Load.

30 days at 10 hours.....	300 hours
25 kw. demand, 25 x 300.....	7,500 kw. hr.

Power Load.

Two shift (30 days at 16 hrs.).....	480 hours
480 hours (100 kw. demand, average).	48,000 kw. hr.
Total average monthly load.....	55,500 kw. hr.

Summary of Cost as Per Above.

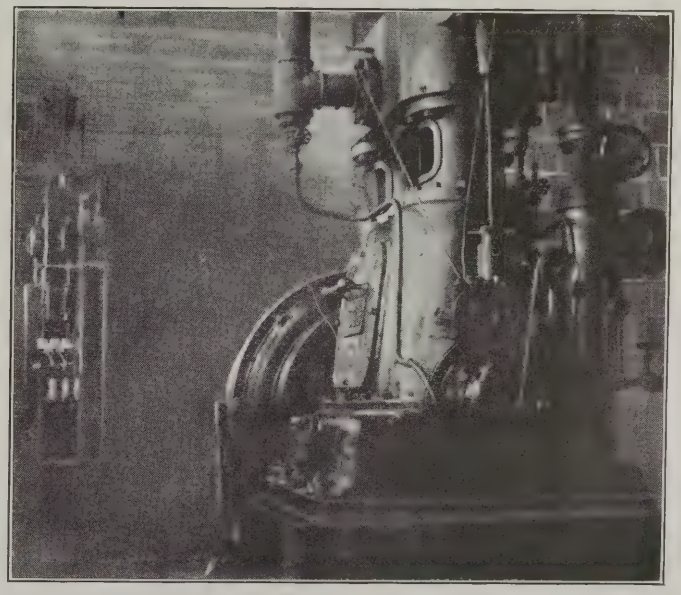
Fuel	$333.00
(a) Fixed Charges	200.00
(b) Labor	229.60
(c) Overhead	183.68
(d) Waste, Oil and Repairs.....	138.75
	$1,085.03

Total cost per kw. hr. will then be:

$1,085.03 divided by 55,500, or 1.9569 cents per kw. hr.

This figure would vary of course according to the amount of labor chargeable, and would be in proportion to and conversely with the ratio of the steam requirements of prime mover used with the electric generator. Investigation of a number of plants of this character would show that this total figure of 1.9 cents per kw. hr. would rarely rise above 3.5 cents if the correct proportionate charges were made against the different portions and auxiliaries of the roundhouse.

The question will probably arise in the minds of some readers as to why install generators other than to provide artificial lighting which would be taken care of by means of a 15 kw. unit set? There are a number of reasons why. To begin with, most classification yards cover a wide area extending a mile or so one side of the roundhouse, the station buildings are located some distance away. Auxiliaries, such as coal handling plants, repair yards, etc., are also subject to distance; the natural thing to take care of the lighting of these is to use a. c. energy, especially if consideration of voltage drop, economical use of copper, etc., is going to rule. As a. c. generators are seldom made much below 30 kw. sizes, and as it is generally found by experience that if power of this kind is available, there is at once a distinct and pressing demand for the addition of small motors to the many needs that are found around such a plant, it follows that the designing engineer will put in a larger plant than at first might seem necessary. It will be soon found that this foresight will mean a saving in applications



A Typical 50-Kw. Compound Engine Generator Set

such as water pumping plants located some distance away, where full control can be arranged from the switchboard at the roundhouse, thus doing away with hauling and labor charges at the pump house itself.

Small towns with their appreciation of the advantages of electric energy, if located at these points, very soon begin to make inquiries as to the purchase of power for lighting and domestic purposes. There is a distinct advantage to the small towns if they can purchase energy from such a plant in that 24-hour service is required as a rule by the railway, and therefore would be available to the town. Such service as this in the ordinary course of small town enterprise is almost impossible and therefore usually limited to sunset to sunrise schedule, and sometimes only from sunset to one o'clock a. m.

Railroad franchises usually carry clauses which place legal technicalities in the way of supplying energy in this manner, with the idea that a railway should not enter into competition with private enterprise. This idea should be kept up to a certain extent, but no further, for

where conditions are such that a town has a population of 5,000 or less, benefit would accrue to both the railway and town if the former supplies electrical energy for domestic consumption.

Next comes the question of policy in the distribution and metering systems, and the consequent office and billing charges. This is the part that should be taken care of by the town. The railway should sell the energy at the switchboard at a wholesale rate only, and its responsibility should cease from there on. This rate could be a nominal charge, say 5 cents per kw. hr., on a flat rate or sliding scale, whichever is found necessary. The town itself can possibly finance and manage this part by means of bond sales or it can franchise this utility to private interests.

Finally, the question of control of the development of electric supply in small towns located away from railroad divisional points comes to the front. This matter becomes a question as to the cost of the fuel to be used, the area to be covered by the distribution system, the number of consumers and the type of plant to be installed. As a rule it will be found that a steam plant, unless located in a coal mining area where fuel is cheap, would be out of the question. There are only three sources of power left, and of these the hydro development, unless extremely favorable to local conditions and small capital outlay, would carry too high a fixed charge with it to enable energy to be sold at a reasonable figure. A gas producer plant might be suitable in some locations but it should be remembered by the designing engineer that depreciation is fairly high on the producer, scrubbers and tar extractor portion of the plant. Experienced labor is required and more of it than in fuel oil plants, and where the rates chargeable might be favorably influenced by the economy of fuel cost they may be unfavorably acted upon by high investment, labor and repair charges. The oil plant would probably be the most satisfactory in the majority of cases, because of its comparative simplicity, small investment charge and also, which is important, the fact that labor of an experienced nature can quickly be found for its operation and upkeep.

As each problem would be always a matter of local conditions it would be impossible to propose a standard plant or standard system of distribution. Such propositions should be subject to some form of control from a central advisory engineering department. Such an engineering department should not design such plants, but should have designs of consulting engineers submitted to it in order to suggest the necessary constructive criticism and improvements, to better the standing of this particular type of small town plant and to create a better financial standing and thought towards such ventures.

The rates to be charged locally at each plant of this description could be properly mapped out, allowing enough to take care of the depreciation, repairs, interest on capital, operating and distribution costs, and also office charges. We would then be able to state the cost of service on a correct engineering basis, because after all the financial end is of just as much importance as the correct type of prime mover if the promoters of the plan are really to fulfill their responsibilities to the public at large.

Justice can only rise on the scales of Equity in the proportion the weight of prejudices is dropped on the other side.

Eleventh Annual Reunion of the Retired Employees' Association of the Pennsylvania

Proposed Reorganization of the Port of New York

Special Automatic-Electric Subway System Feature of the New York-New Jersey Commission Report

AFTER more than three years' intensive study and planning, the New York-New Jersey Port and Harbor Development Commission has completed its plan for the reorganization of the Port of New York and has submitted it to the state legislatures. The report covers not only the plan recommended, but also contains the results of studies relative to possible solutions to the problem by means of overhead and underground systems connecting New York and New Jersey for the use of

Initial Development of the Automatic-Electric System

standard equipment; motor truck service; cableway truck conveyor service and improved water transfer service, all of which, however, were found unsuitable.

The New York-New Jersey Port and Harbor Development Commission consists of William R. Willcox, chairman; J. Spencer Smith, vice-chairman; Eugenius H. Outerbridge, DeWitt Van Buskirk, Murray Hulbert and Frank R. Ford. Major-General George W. Goethals is consulting engineer; B. F. Cresson, Jr., chief engineer; Julius Henry Cohen, counsel; William Leary, secretary, and C. A. Ruhlmann, assistant secretary.

The Comprehensive Physical Plan

A complete reorganization of the railroad terminal system is the most fundamental physical need, such a reorganization involving new methods of handling freight from the break-up yards of the railroads. The plan recommended calls for improving and opening up for joint use the existing belt-line links in New Jersey and constructing other belt lines along navigable New Jersey waters and farther inland; building similar marginal railroads along navigable waters adjacent to Brooklyn, Queens, Staten Island and the Bronx and utilizing with them the Long Island and the New York Connecting Railroad to form a belt-line system in New York; connecting the New Jersey and New York belt systems, at first by car ferry and ultimately by tunnel under the Upper Bay; operating all of these lines jointly and operating jointly, through new joint railhead terminals, all railroad marine service not replaced by other service; and building an underground railroad system carrying special electrically operated cars, connecting with all of the railroads of the port, serving virtually all of Manhattan and enabling the railroads to discontinue their pier stations and consequently release the waterfront to other uses.

Present Railroad Operations

Twelve railroads, exclusive of purely local enterprises, come to the Port of New York. Nine of these enter the district from New Jersey, have their railheads in New Jersey or Staten Island, and are referred to as the New Jersey railroads. The remaining three enter from New York, terminate in New York, and are referred to as the New York railroads.

The commission's analysis, which it believes to be more accurate than any previously attempted by any agency, gives the following figures for operating costs in 1914: For goods handled at Manhattan car-float pier stations or inland rail stations, $1.60 per ton; for goods handled at Brooklyn, Harlem or Bronx stations, $1.48 per ton; for goods lightered, $2.14 per ton.

On the basis of 1918 prices, which are obviously much higher than those of 1914, the commission estimated that the total terminal costs to the railroads were about $2.25 per ton for freight handled to or from Manhattan stations, $2.08 for that handled to or from Brooklyn, Harlem or Bronx stations, and $3.01 for freight lightered. Considering the tonnage at the Manhattan stations alone, which amounted in round numbers in 1918 to 8,500,000 tons, the cost of the terminal operations at $2.25 per ton was about $19,125,000. Assuming an average terminal allowance for this freight of 75 cents per ton, the total allowance would be $6,375,000 and the deficiency of the terminal charge in the single year on the one class of freight would be $12,750,000.

Initial Development of Automatic-Electric System

In the initial development it is proposed to link up the New Jersey railroads by a belt line along the eastern margin of the Hackensack Meadows and build a joint railroad yard in New Jersey east of the Croxton yard of the Erie. The automatic-electric tracks will start from this joint yard in New Jersey, pass under Bergen Hill and the Hudson River to a point in Manhattan at about Forty-seventh street, thence turn southerly and pass under certain streets suitable for the location of convenient terminals, turning back to the joint yard via another set of tunnels in the vicinity of Battery Place.

A consignment of freight for one of the Manhattan

terminals, coming in a train with freight for other parts of the port district, will enter the existing break-up yard of the railroad company. Here the standard railroad cars will be classified as at present, and the car containing this shipment, together with others containing other freight for Manhattan, will be delivered to the public or private company operating the terminal system at the intersection of its belt line with the railroad company's line. The standard railroads cars will be hauled to the joint yard and placed in a receiving yard, whence they will be switched to tracks alongside the inbound ends of long transfer platforms.

Each of these platforms, 24 in number, will have a standard-equipment track on one side and an automatic-electric track on the other side. The freight will be unloaded from the standard railroad car upon trailers about 3 ft. by 6 ft., and the trailers will then be hauled by tractors or by hand along the platform and placed upon one of the automatic-electric cars, which will hold 12 trailers. The standard railroad car will be pushed along the platform to the outbound end and reloaded with outgoing freight from other trucks, whence it will pass into an advance yard and be despatched to the railroad from which it came, or to any other railroad to which it is to be delivered.

The consignment of freight will meanwhile have been loaded upon one of the special electric cars—a car somewhat larger than the ordinary box car, with a roof to protect its contents, but roll sides to permit trailer trucks to be wheeled upon it at any point.

This car, controlled from alongside by a switch on the car within reach of an operator on the transfer platform or on the ground, will move from the platform at a low rate of speed (from 2.2 to 6.6 miles per hour) and be switched to a track assigned to the particular terminal to which the freight is destined, freight for only one terminal having been placed on the car. When sufficient automatic-electric cars have been accumulated, eight will be coupled together and despatched in a train. This train, with no other manual direction than the throwing of the track switch, will be accelerated to a speed of 1,200 ft. per min. (13.2 miles per hour) and take its place at not less than an established distance behind another train probably destined for a different terminal. The train will bear a distinctly visible indication of its destination, and when it reaches the entrance of its terminal an operator will throw a switch and divert it to a siding, where brakes will automatically be applied and it will come to a stop.

From this siding the automatic-electric cars will be run singly at slow speed upon an elevator. The elevator will raise the cars one at a time to an inbound platform at the street level and the cars will be run off under their own power. This platform will be the length of several cars, and each car will remain alongside the platform a minimum of 12 minutes, affording ample time for the wheeling off of the trailer trucks and the wheeling on of empty trucks. The consignment will be placed on the platform to be called for, as at the ordinary freight house, or removed to storage if the consignee fails to call for it within the free time limit.

The automatic-electric cars, having discharged their loads and received empty trailers, will be advanced one by one to a second elevator, which will lower them one floor to the outbound platform at the basement level. Here the cars, after having again at least 12 minutes in which to unload their empty trailers and receive loaded trailers with outbound freight, each car receiving freight for a single railroad, will proceed back to the original elevator shaft. The cars will then be run upon the first elevator and be lowered to the track level, this elevator having meanwhile made several trips and brought other cars to the inbound level.

Running off the elevator at the side-track level, the automatic-electric cars will be held until eight have accumulated, when they will be coupled and despatched as a train by exactly the same process as from the New Jersey yard, an interlocking signal system controlling the time when the train shall enter the main-line system.

Arriving at the joint yard, the train will be switched to one of the tracks of a receiving yard, where it will be brought to a stop automatically as before. Here the automatic-electric cars will be cut off one at a time, and started by an operator walking alongside, the cars moving at a speed of 2.2 miles per hour. They will proceed over a series of switches and crossovers, controlled from a central tower, by which they will be diverted to the proper tracks at the transfer station.

The cars will be stopped at the outbound ends of the transfer platforms. The loaded trailers will be removed and transferred to standard freight cars, other trailers previously emptied will be hauled by tractors along the platform to the inbound end of the platforms, the empty automatic-electric cars will be advanced to the inbound section of the transfer station to receive new loads, and the cycle will have been completed.

Electrical Features

The system can be operated by either direct or alternating current, but the latter seems better adapted and has been assumed in the estimates. If alternating current is used it will probably be generated and transmitted at 13,200 volts and stepped down at frequent substations to the voltages ranging from 550 down to 135 required in operation. The cars will receive their power through pantagraphs from two overhead trolley wires. Each car will be equipped either to run singly or to haul something more than its own weight in a train, so that one or two standard railroad cars can be made part of an eight-car train.

In order that the uniform speed necessary for the correct spacing of the various kinds of trains can be maintained, it is proposed to use squirrel cage induction motors of moderately high torque, two to each automatic car. These motors will be designed as to give good operating characteristics over a range of frequency of 60 cycles down to 10 cycles, the voltages being reduced in the correct proportions. On the main tracks, where a speed of 1,200 ft. per minute is to be maintained, the power will be supplied at 3-phase 60 cycles, 550 volts, while on sections where the desired speed is 200 or 600 ft. per minute, the power will be supplied at correspondingly lower voltages and frequencies.

It will be necessary to distribute the power at high voltage and step it down to track voltage at short intervals in order to prevent excessive voltage drop in the trolley wires and tracks. Each car will have a simple reversing switch for its two motors, so that when on the low-speed sections of track an operator will be able to start, stop or reverse the car at any time. Each of the

two motors will be provided with a delayed-action solenoid brake, so that when the power is shut off the car will coast a short distance before the brake takes hold and brings it to rest. This delayed action is necessary to allow the car to coast over dead sections of track which will be necessary at various points.

Movements of the cars singly at the 200-ft. speed will be accomplished by the simple process of having a man standing or walking alongside throw a switch on the car. The car will be under manual control at all times, but will not require a rider, and can be sent considerable distances from one operator to another.

Acceleration and Deceleration

Acceleration and deceleration of the mainline eight-car train to and from the speed of 1,200 ft. per minute will be effected by means of a special section of track energized by a motor-generator set whose motor is of the variable-speed, direct current type—the motor generator being set under the complete control of the chief train despatcher, but operating automatically as the switches are turned.

When the cars on the forwarding tracks are made up into eight-car trains, the current will be cut off from the track on which the train is standing and the switches of all eight cars will be closed in the forward direction. The chief despatcher, by means of the motor generator set, will energize the track at 10 cycles, 135 volts, which will begin accelerating the train. The speed of the motor generator set will automatically gradually raise the power supply to 60 cycles, 550 volts, which will bring the train to its full speed of 1,200 ft. per minute. All of this will be accomplished at a rate of acceleration of 1 ft. per second or in a distance of 200 ft.

When the train has obtained its full speed, it will run off the make-up track and enter the main track, when it will continue at this speed without further attention until it is switched into a decelerating section, while the motor generator set will be released for use in accelerating the next train.

In the decelerating sections the process will be reversed, a variable speed motor generator set reducing the frequency from 60 cycles to 10 cycles and bringing the train to rest in 200 ft. after the deceleration is applied.

Where individual cars must be accelerated from a speed of 200 ft. per minute to one of 600 feet per minute in the New Jersey yard, the headway is too short for a variable speed motor generator set; hence it is proposed to use sectionalized tracks with different frequencies on each section. For example, a yard man will despatch a car on a 10-cycle section by closing the car switch and the car will automatically accelerate to 200 ft. per minute. At the desired point it will enter a section of track energized at 30 cycles, and with the correct operating voltage for this frequency. This will accelerate it to approximately 600 ft. per minute. Again, the car will enter another section energized to 10 cycles and 135 volts, and its speed will be automatically reduced to 200 ft. per minute. All of this will be accomplished with no man control other than the original starting of the car.

Trailing Dead Sections

Ordinarily the eight-car trains, moving at a uniform speed varied only slightly by different conditions of load and grade, will maintain their proper spacing and be safe from collision. Provisions must be made, however, for the protection of trains brought to a stop through derailment, burned-out motors or other causes. This provision is made by the ingenious use of trailing dead sections.

Throughout their length the main tracks will be divided into insulated sections of a train length plus the distance required to bring the train to a standstill from full speed. The electrical circuits will be so arranged that the current will be completely cut off from the second section behind each train, this dead section advancing as the train advances. If through any accident or error in despatching, a train should come within the established distance of train ahead, it will run upon this dead section and be stopped by the application of brakes. When the train ahead gets far enough in advance, the dead section of track will automatically become energized and the train which has been stopped will be started and brought to speed again.

These dead sections, besides protecting trains stopped on the mainline by accident, will prevent the despatching of a train from a terminal too close to the train ahead of it or behind it, the system in effect interlocking the forwarding tracks with the main tracks. If for any reason all trains are stopped, all will automatically start in the correct sequence, and with safe spaces between them when the power is turned on again.

Trailing Light System

Supplementing the trailing dead sections will be a trailing light system. In front of the chief despatcher's desk will be a large sectional map showing the entire main trackage of the system. As each train is despatched from any point on the system, a light will appear at that point on the map, and will follow the track in such a way as to show at all times the location of that train. If for any reason the train comes to a stop, the light will stop and will indicate to the chief despatcher that there is trouble at that particular point, since no trains are supposed to stop on the main track.

Thus the trailing dead sections will prevent collisions, and the trailing light system will enable the despatcher to send repair men immediately to the point of trouble. In this way detention will be minimized.

Power Stations

As the commission's investigation of existing electric power plants in the port district showed that there is no surplus power available for such a large plant, it is assumed that a power plant will have to be provided. A break-down connection should be obtained with existing power companies as a reserve source of power.

The main power station of the system will be located at the New Jersey yard. It will contain standard turbine-driven alternators generating power at 60 cycles and probably at 13,200 volts. Motor generator sets will then be used for obtaining the necessary direct current and the various frequencies as required.

The power supply for the Manhattan side will be transmitted through lead-covered cables running in the tunnels at 13,200 volts, 60 cycles. The Manhattan substations will contain the necessary transformers and motor generator sets for accelerating and decelerating the trains and for obtaining the permanent 10-cycle terminals. The elevators in the terminals will presumably also ob-

tain their power from the transformer stations. For the 12 terminals there will be 12 substations.

Special Equipment

Under the head of special equipment for moving the freight by the automatic-electric system, there will be required 1,030 special cars, 380 platform tractors, 30,000 trailers and 48 car elevators. This does not take into account ordinary truck elevators in the terminals for serving upper floors.

It is estimated that 900 special cars, 305 platform tractors and 25,000 trailers will handle peak load, and consequently there is a liberal allowance for spare equipment.

Automatic-Electric Cars

It is proposed to make the automatic-electric cars 58 ft. long between centers of couplers and 8 ft. wide, which will make it possible to run upon them two trains of six 3 ft. by 6 ft. trailers. No working space need be provided for car riders.

As all kinds of general merchandise freight will be carried on the trailers, and as the tracks are on the surface in New Jersey, on fenced-in right-of-way, the cars will have to be roofed. It is proposed to make them of all-steel construction, with rolling sides for the entire length. It is important that there be no obstacles in the way of rapid moving of the trailers on and off the cars, inasmuch as the cars cannot ordinarily stand more than a few minutes in one position.

Presumably there will be more than one type of car. Certain bulky packages—anything that can be handled in an ordinary box car—and also motor truck bodies to be delivered at the Manhattan terminals to motor truck chassis for delivery at store door will be loaded upon the cars direct, without the use of the trailers, and for such commodities it will be desirable to have a minimum number of side posts or eliminate the side posts and roof entirely. Other cars will require refrigerator bodies for perishable freight. For estimating purposes the cars are assumed to be all of one type.

Trailers and Tractors

For the trailers simple 4-wheel low platform trucks with end frames to hold the loads are recommended. Platforms 3 ft. by 6 ft. or slightly smaller will be a convenient size for use on the automatic-electric cars and for running into and out of standard freight cars. The distances these trucks must travel, especially on the 2,000-ft. platforms of the New Jersey transfer station, make it desirable that manual operation of them be minimized. It is proposed, therefore, that they be hauled by storage battery electric tractors in trains of from four to six trailers.

In loading an automatic electric car, the tractor will probably be able to haul two 4-trailer trains on the middle of the car, while the remaining two trailers at each end will have to be put on by hand.

Elevators

The elevators will be electrically operated platforms 12 ft. by 60 ft. with micro-leveling devices so that they can be brought quickly to a standstill at the exact level required to move the cars on and off, and with interlocking devices to prevent movement of the elevators when the cars are not in proper position. They are designed for an operating speed of 100 ft. per min.

In each terminal there will be two elevators running down to the tracks and two shuttle elevators. In the entire system there will thus be 48 elevators. Elevators of this capacity are in service at various points, and they present no serious obstacles. Momentary delays in their operation can be absorbed by subsequent speeding up and the use of the extra receiving and forwarding tracks at the terminals. More extended repairs can be made at night. A breakdown of 3 or 4 elevators at one time, which would be unlikely, would reduce the total output of the terminal plant, but in no such degree as it is reduced frequently under present methods by fog, ice or other adverse conditions.

Replacing Defective Insulators

BY means of the improved appliances insulators on live high-tension lines can be tested while in position and the defective insulators weeded out and replaced with good ones.

Several different methods are used to test and change the insulators, the fundamental principle of them being that there is always a long insulating rod or other appliance between the man and the live part upon which he is to work. Various patented devices in the shape of tools are used on the ends of insulating rods for removing and replacing tie wires on pin type insulators and for removing and replacing cotter pins on suspension type insulators. Special long-handled testing poles for picking out defective insulators are also on the market. In testing insulators on live lines advantage is taken of the fact that a difference of potential exists between the cap and pin of a disc insulator. A wire fork on the end of an insulating pole is used in some cases for making the test, placing the wire across the insulator between the cap and pin. If the insulator is good a static spark is obtained, and the absence of spark or a weak spark shows that the insulator is defective.

The following is a brief description of one of the methods used to change defective insulators on high-tension lines. The insulators are first tested and the defective ones noted, a record being kept of the pole, or tower, and the position of the insulators. A crew, generally consisting of six men and the foreman, do the work of changing the insulators. First, long insulating rods are attached to the wire and the line secured in position and held so that it cannot swing into the poles or towers. By means of rope blocks the rods are made to force the wire upward and away from its regular position. The insulator is then disconnected from the wire, after which the insulator can be removed and replaced or any necessary changes made. With proper tools it is not necessary for any of the workers to approach or place their hands or any part of their body within dangerous proximity of any live conductor.

Noise and static on or around lines and insulators indicate trouble, and it may be due to defective insulators or to an "arcing" ground on the high-tension lines. Foremen should instruct their men to work with extreme caution at such times. It is generally advisable to stop the regular work of changing insulators until the cause of the trouble has been located, a precaution heeded on systems with a grounded neutral.—*Electric Traction.*

Electric Rivet Heaters for Car Construction*

Feeders Carried in Concrete Trench. Rigid Conduit Used for Temporary and Permanent Branch Runs

By J. R. Bower
Assistant Master Mechanic, American Car and Foundry Company

ELECTRIC rivet heaters were in use in the Berwick shops of the American Car and Foundry Company as early as 1911, but were not used to equip an entire department until 1914. At this time the passenger car erection department was equipped complete and all the rivets required for passenger cars from 1914 to the present have been heated by electric rivet heaters.

During the past year the entire freight car construction and erection departments have been equipped with electric rivet heaters, so that all the rivets used on the freight cars going through this shop are now heated by electricity.

At the present time the Berwick shops have the largest installation of electric rivet heaters in the world. This, however, is not caused by a demand for a larger number of heated rivets than some of the other large companies, but simply due to the fact that rivets were heated electrically by point of high resistance for commercial use in Berwick before they were ever heated by this method in any other place in the world, this being accomplished by machines designed and built in our own shops. Due to this fact we should be the largest user until the great advantages of electric rivet heaters are thoroughly grasped by the various users of heated rivets.

General Principles of Construction

The general principles of construction of the heaters consist of a transformer wound with a number of turns on the primary coil which is excited by 220 volts, the secondary coil consisting of one turn. The placing of a rivet in the circuit on this one turn of secondary completes the circuit and due to the high resistance of the rivet causes same to heat. The placing of this rivet in the secondary circuit is accomplished by the use of a short pair of tongs and by pressing a pedal with the foot which opens the electrode on the secondary circuit allowing the rivet to be held firmly in this electrode. These heaters have at the present time from one to five of the secondary coils, according to the design or size required for the particular work that is to be accomplished.

These heaters have gone through a series of alterations and developments since the first ones were built in 1911, but this has all been details which I do not think it necessary to bring out in this paper, the object of which is to try to bring out the particular advantages of the electric rivet heaters over other methods of heating rivets, especially oil; this from a viewpoint of the installation in our freight car department which consists of approximately fifty-five heaters at the present time.

A Practical Installation

The freight car department will be considered, instead of the passenger car department, because the passenger car department is not working at this time. However, if the passenger car department were used, the argument would be much greater in favor of electric heaters, as the number of pounds of rivets per oil furnace on passenger cars is much smaller than in the freight department, due to the rivets being of much smaller size. A complete lay-out of the wiring, both 2,200 and 220 volt circuits, as well as an indication of the location of the heaters, transformers, etc., with relation to one another is shown in Fig. 1. The 2,200 volt line extends along the outside of shop on poles and drops in at different points to the three transformer banks. This line is 60 cycle, 3 phase alternating current. The transformers are all connected closed delta primary and secondary, making a three phase, 220 volt secondary line to which the individual heaters are tapped on the various phases, so that each phase is balanced in relation to the other two phases. There are two buildings connected to this line besides the rivet heaters which have a total of 95 kw. connected load.

The group of heaters on the bank of transformers at

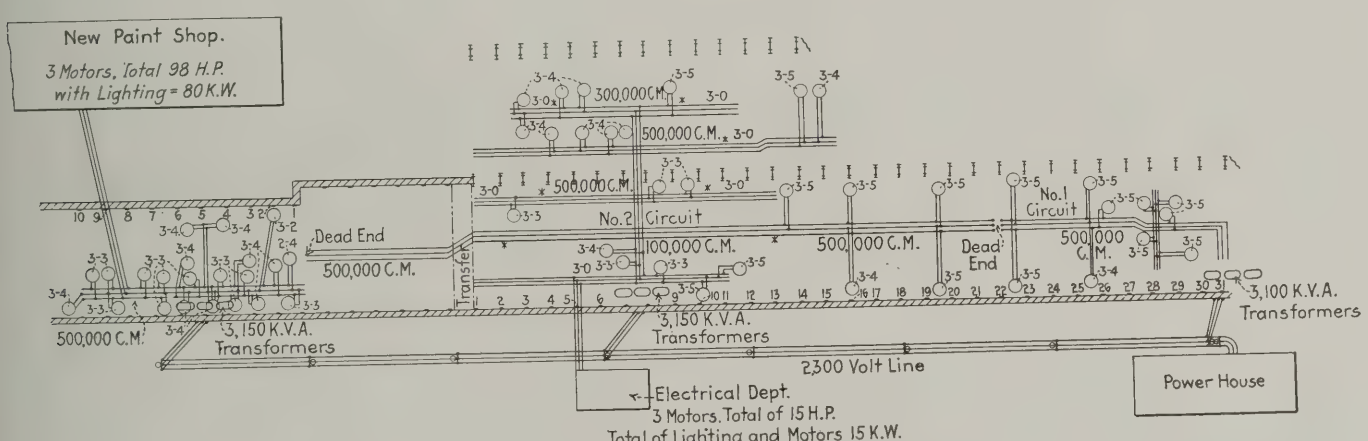


Fig. 1—Shop Wiring Diagram Showing Circuits and Location of Transformers and Rivet Heaters

*Abstract of a paper presented before the Philadelphia Section, Assoc. of Iron and Steel Electrical Engineers, at the Engineers' Club of Philadelphia.

the extreme left have the secondary line secured to the steel truss work of the building overhead. This is due to this section of the shop being much lower in height than in the other part of the shop, and there being no overhead cranes in this section it is very easy to run risers from the heaters to the main feed wires overhead. The groups of heaters connected to the middle bank of transformers, as well as the bank to the right of illustration, have all the three phase lines in a concrete trench, a cross section of which is shown in Fig. 2.

This trench has a cover of wood which has a quarter inch armor plate exposed to the surface and the trench is so located in the floor that the top is just flush with the surrounding floor space. At intervals of approximately

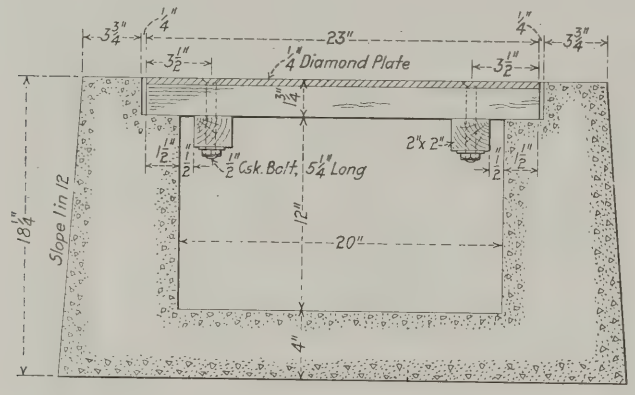


Fig. 2—Cross Section of Concrete Trench in Which Feeders Are Laid

ten feet distance on each side of the trench, there are holes in the side wall about two and one-half inches in diameter. These are all plugged with wood plugs except the places where the heaters are to be installed. At this point the plug is removed and conduit is laid in the ground to the point where the heater is located, the conduit coming up at a right angle bend and extending about four feet above the surface of the floor so that it will terminate just at the end of the heater, near the top. At this point

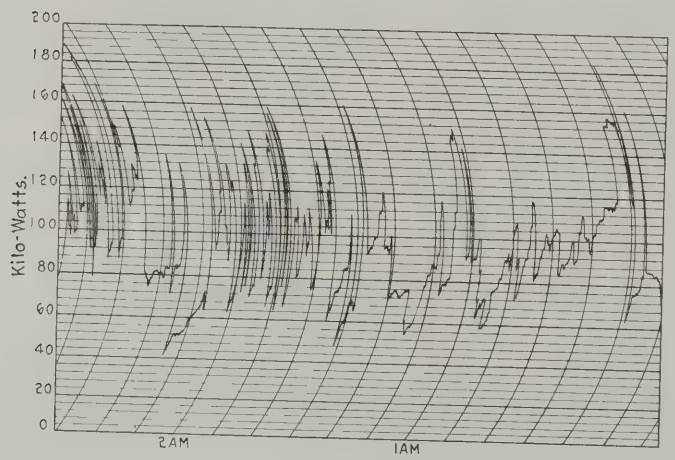


Fig. 3—Chart Showing Power Consumption at the Bank of Three 100 k.v.a. Transformers Shown in Fig. 1

on the end of the heater a double pole knife switch is placed so that the current can be cut off the heater at any time. If a heater is to be moved to another location all that will be necessary is to disconnect the wires in the trench feeding this particular heater, take out the conduit, plug up the hole and locate at another position and connect up with longer or shorter conduit as the condition may require.

Work Accomplished Compared to Kw. Hrs. Consumed

The lay-out of heaters as shown in Fig. 1 are at the present time heating rivets for 59 freight cars per day, 22 N.Y.C. hoppers on one track, 27 tank underframes on

Fig. 4—There Are Three Men Instead of Four in a Riveting Gang

another track, and 10 cane cars on a third track. The 22 N.Y.C. hoppers have a total of 2,540 rivets per car, ranging in size from ⅝" x 1½" to ⅞" x 3¾", representing 25,146 pounds of metal. The 27 tank underframes have a total of 816 rivets per car, ranging in size from ⅝" x 2" to ¾" x 3¾" and ⅞" x 3½", representing 11,236 pounds of metal, also 4 special rivets per car 1¼" x 13½",

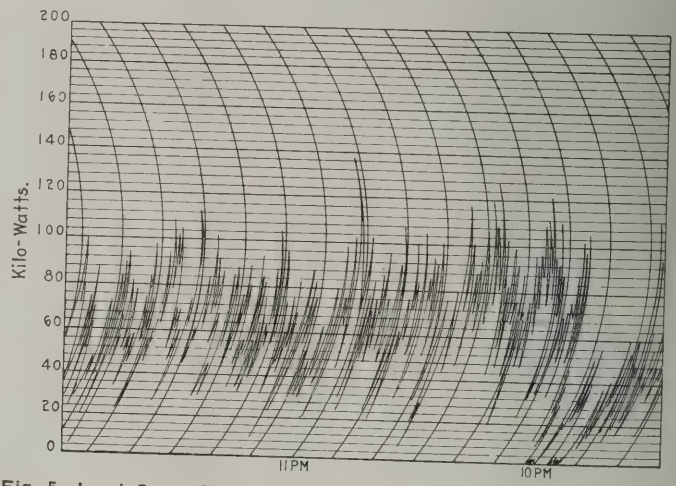


Fig. 5—Load Curve Taken from the Middle Bank of Transformers Shown in Fig. 1

a total of 108 rivets, representing 540 pounds of metal. The 10 cane cars have a total of 2,405 rivets per car, ranging in size from ⅜" x 1½" to ⅞" x 2¾" representing 8,816 pounds of metal, making a grand total of 102,070 rivets, representing 45,739 pounds of metal requiring 6,370 kw. hr. to heat these rivets. This gives us an average of approximately 14 kw. hr. per hundred pounds. There is a small percentage of rivets heated in addition to the amount mentioned above that should be counted in against the number of pounds for the given kilowatt hours, as there are always a few

rivets heated the second time, due to the rivet gang not being ready when the rivets are ready for them.

Power Characteristics

Some of the power characteristics as found at different points in this installation are particularly interesting. Fig. 3 shows a graphic chart of five minutes to the hour taken at the bank of three 100 k.v.a. transformers as shown in Fig. 1. You will note that the power curve covers quite a wide range on the chart. This is due to the method used in this particular department where bolsters are being built to be used farther down the shop in the erection of cars. Fig. 4 will give you an idea of how this riveting is done. Instead of having a heater boy, sticker, bucker and hammerman, as generally comprises a riveting gang, in this case there are three men instead of four. They start heating rivets at a very high speed, placing them in the holes and then place the bolster under the air or hydraulic bull riveter, as the case may be, and drive them in this manner.

The graphic chart, Fig. 5, shows five minutes to the

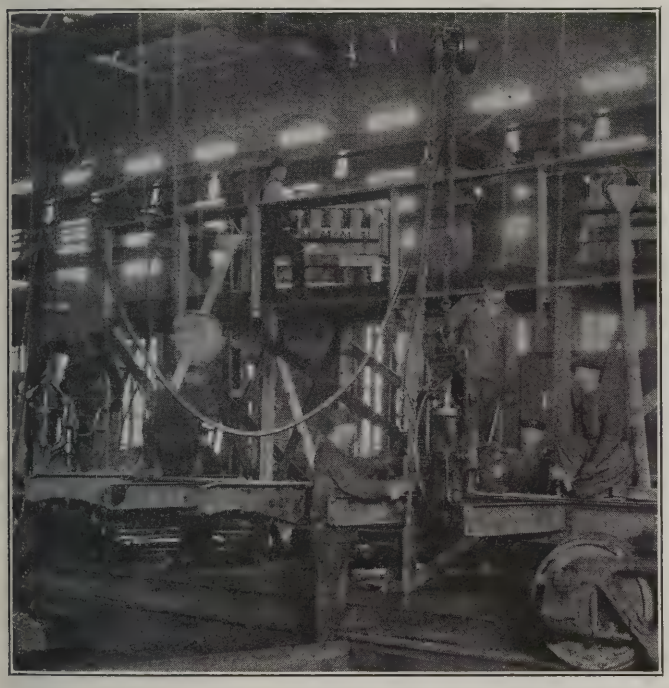


Fig. 6—Where Allen Riveters Are Used the Heaters Are Located on a Platform and the Rivets Are Passed Down a Chute

hour taken from the middle banks of transformers shown on Fig. 1. The fluctuation is also quite prominent in this case as the riveting is partly done in the same manner as in the bolster department, as shown in Fig. 6, where Allen riveters are being used with rivet heaters located on overhead platforms and the rivets being passed down a chute into a small pan where the sticker receives them and places them in the holes in rapid succession. There are also numerous hand air riveters used at this point of the work, as shown on Fig. 7. Taking the three banks of transformers as a whole and reading from the 2,200-volt line we get a chart similar to that shown on Fig. 8. We feel that as the installation becomes larger the fluctuation of the power curve becomes less.

The total load of alternating current 2,200-volt, 3 phase as used from our power house is shown in Fig. 9. The chart shows a full day's operation from 6 A. M. to 6 P. M. The chart, Fig. 10, was taken from the same meter, but on this day it was necessary through a bad primary fuse connection to open the rivet heater line switch. You will note shortly after 11 A. M., when this first happened, just what the drop-off in load amounted to for the fifty-five heaters that are on this line and also that the fluctuation in kilowatts has not ceased entirely, so that the fluctuation on this chart cannot all be attributed to rivet heater load.

Fig. 7—A Part of the Work Is Done With Hand Air Riveters

The second time during this day that this line switch was opened was between 2 and 3 P. M.

Comparative Costs of Electric and Oil Heating

Going back to the power required to heat rivets by this method, we have proved beyond a doubt that it requires between 10 and 20 kw. h. to heat one hundred pounds of rivets, regardless of their size. Therefore, with current from one to two cents per kw. h. the maxi-

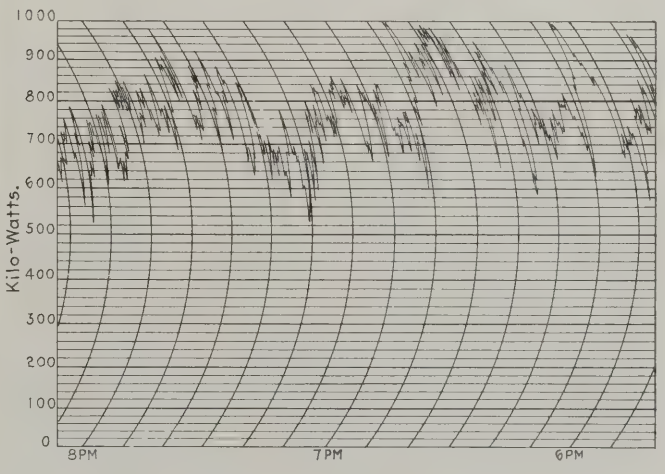


Fig. 8—Load Curve Showing the Combined Load on the Three Transformer Banks; 2200-Volt Side

mum cost per hundred pounds of rivets would be less than forty cents, and up to this time with the late type heaters, which have been in service for approximately one and one-half years, the maintenance cost has been so small that it would be hard to figure per hundred pounds of rivets.

Shortly before the electric heaters were installed in our freight department, we made some tests on oil furnaces in

the same location as the electric heaters are now placed. A very close record was kept of the oil consumed and on the best conditions that we could get with our system. We consumed fourteen gallons of oil per hundred pounds of rivets heated, which at the present market price of oil would range around $2 per hundred pounds of rivets, and this does not include the air blast necessary to make this oil combustible, which would probably add from five to ten per cent. to the cost of this method of heating. We have tried coke as a substitute for the oil, but have found this just as expensive. From a maintenance standpoint, (which this is rather hard to determine unless the test is run over a long period of time,) which consists of rebricking the furnace quite frequently, repair to air line, oil nozzles, etc., and I believe we are safe in estimating from five to ten per cent addition, which would run our cost of oil furnace heated rivets between $2 and $2.50 per hundred tons. This makes a saving in the cost of fuel between oil and electric heated rivets of from $1 to $2 per hundred pounds in favor of the electric. Of course, these figures will vary according to the price of oil, price of electric current and the efficiency of the oil system used when these figures are to be applied to another works.

Desirability of Electric Heating

In regard to the desirability of electric rivet heaters over oil furnaces: the smoke and gas given off by the oil furnaces is very objectionable. Especially is this true during the winter months, when it is necessary to keep the shop closed to prevent heavy drafts of cold air passing through the shop, which would freeze hydraulic and air lines. By leaving the ventilators closed this smoke and gas is entrapped and becomes so thick on winter mornings when the air is cold and oil combustion poor, that it has been necessary to discontinue operations, as it was impossible for the crane operators who work overhead to see the crane director's signals from the ground, to say nothing of the unhealthful condition for the operator. There is also an objection to the oil furnaces in the summer time, due to the extreme heat that is given off, making it almost impossible for the heater boy to stand up to the hot furnace and deliver his rivets as he should. Also very often the oil line becomes leaky around the furnace, allowing oil to drip on the floor, which saturates everything around the furnace. Quite frequently this oil is ignited by hot rivets dropping in these pools of oil, resulting in very annoying fires. Another point is that these oil furnaces must be located at some particular point and piped up for both oil and blast. This does not make them very easy to handle when it comes to changing orders of cars which necessitates rearranging the furnaces. We also very often find rivets coming from oil and coke furnaces which look like the rivets shown on the left hand side of Fig. 11, which have been left in the furnace too long. This very frequently occurs with oil heated rivets. The rivets on the right were heated in an electric rivet heater and are always under the observation of the rivet boy, therefore, there is no excuse for this

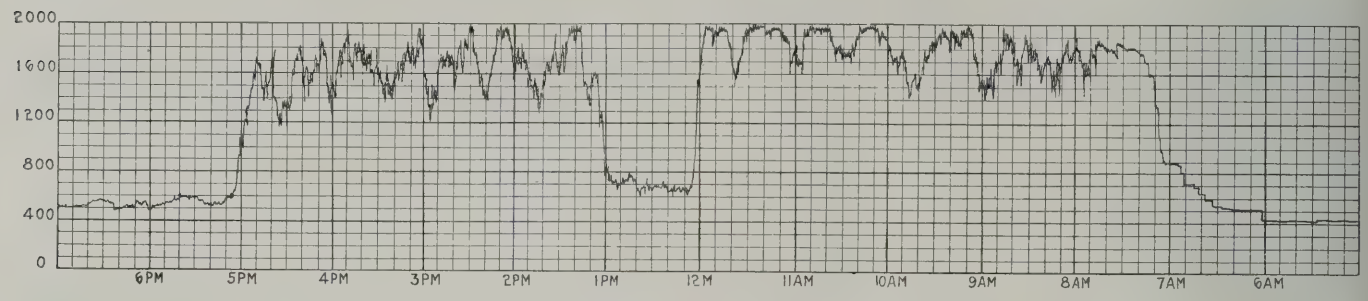


Fig. 9—Total Load of Alternating Current As Used from the Power House

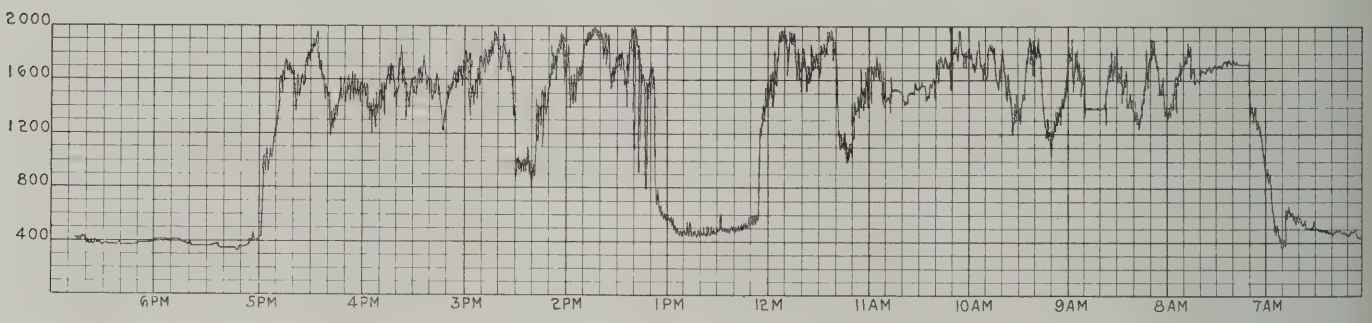


Fig. 10—Total Load on Power House on a Day When Rivet Heater Circuit Was Open Because of Bad Primary Fuse Connections

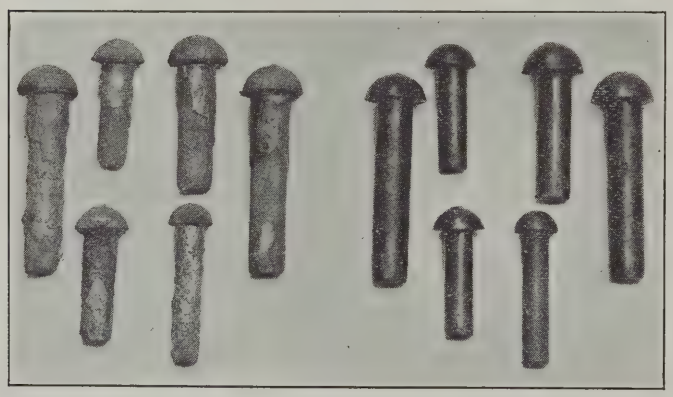


Fig. 11—Rivets Coming from Oil and Coke Furnaces Often Look Like Those at the Left

to happen where the rivets are heated with an electric rivet heater.

The electric rivet heater is very adaptable for moving from place to place, as there are no oil lines or blast lines to be connected, but simply an electrical connection which can be made permanent by the use of conduit, but for a quick change could be connected to a pair of electric wires on short notice.

In regard to the gas and smoke, this is entirely eliminated by the electric furnace which also makes it unnecessary to have furnaces heated up from a half hour to an hour before rivets are actually required, as all that is necessary is to place the rivet in the jaws of the heater and hot rivets are available in from fifteen to forty-five seconds. These various advantages make the once dirty, grimy shop a clean and sanitary place to work.

Report of Progress Made on the Superpower Survey

One-Third of Class 1 Railroads in Boston-Washington Region Can Be Economically Electrified

ACCORDING to a progress report on the work of the Superpower Survey, just submitted to the President by John Barton Payne, ex-Secretary of the Interior, one-third of the mileage of Class 1 railroads in the Boston-Washington industrial region apparently can be economically electrified at a cost of approximately $800,000,000, which, with salvage, would be reduced to $650,000,000, effecting a saving equal to approximately 14 per cent on the investment. The cost of electrifying the railroads within the region is estimated at $40,000 per mile.

The Congress, in appropriating for the Geological Survey, June 5, 1920, provided for the survey of power production and distribution in the United States, including the study of methods for the further utilization of water power and the special investigation of the possible economy of fuel, labor and materials resulting from the use in the Boston-Washington industrial region of a comprehensive system for the generation and distribution of electricity to transportation lines and industries.

An organization was effected under the Geological Survey with offices for the engineering staff in New York City. The engineering staff includes: William S. Murray as chairman; Nathan C. Grover, the chief hydraulic engineer of the United States Geological Survey; Ozni P. Hood, chief mechanical engineer of the Bureau of Mines; Lorin E. Imlay, division engineer for the subjects of power and transmission; Henry W. Butler, division engineer for industries, and Cary T. Hutchinson, division engineer for railroads, with Henry Flood, Jr., engineer-secretary. The engineering staff has been aided by the hearty co-operation of an advisory board of business and professional men, who accepted appointments for this special service. Of this board Prof. Lester P. Breckenridge, of Yale, is chairman, and the various interests connected with this investigation are represented as follows: Magnus W. Alexander, of Boston, representing the National Industrial Conference Board; Edward G. Buckland, vice-president, New York, New Haven & Hartford Railroad; Charles L. Edgar, of the Boston Edison Company, representing the National Electric Light Association; Abraham T. Hardin, vice-president, New York Central Railroad; Herbert Hoover, representing the mining industry; William Kelley, lieutenant colonel, U. S. A.; Elisha Lee, vice-president, Pennsylvania Railroad; Dr. Arthur D. Little, of Boston, representing the electro-chemical and by-products industries; James H. McGraw, president, McGraw-Hill Company, Incorporated, representing the technical press; John H. Pardee, of New York, representing the American Electric Railway Association; Henry Cleveland Perkins, of Washington, representing the mining industry, and Matthew S. Sloan, of the Brooklyn Edison Company, representing the National Electric Light Association.

The progress thus far made, Secretary Payne says, warrants the belief that the report will be completed by June 30, 1921.

Having in mind the object of the Superpower Survey, viz.: (1) allocation and amount of waste in labor, coal and other materials, due to the improper form of power generation and distribution within the Boston-Washington zone, and (2) recommendations regarding a regional power system by means of which these wastes may be eliminated, the report naturally divides itself into three divisions: (1) Physical, (2) Legal, and (3) Financial.

With regard to the physical aspect, the investigation has been concerned with the power necessary to (a) railroads, (b) industries, (c) utilities, and (d) a system of centralized electric generation and transmission to supply their power requirements up to and including 1930.

Railroad Electrification

Regarding railroad electrification, the report says:

We find that there are 20 Class 1 railways included in the Superpower zone. These are divided as follows:

First track 14,500 miles.

Second track 6,500 miles.

Total trackage (including yards and sidings) 36,000 miles.

There are a total of 10,000 steam locomotives, of which 44 per cent are freight, 29 per cent passenger, and 27 per cent switching.

The total annual railroad coal consumption for 1919 was 19 million tons.

Apparently one-third of this mileage can be economically electrified, including the greater part of double track mileage. Due to lack of traffic density upon the branch lines these can not be profitably electrified.

The above 33 per cent of mileage will carry more than 50 per cent of the traffic and by preferential arrangement of routes probably 60 per cent of the total traffic could be put over this mileage.

Through the electrification of the above mileage a fuel saving of 6,000,000 tons, or $40,000,000 per annum would be effected. Added to this saving will be $50,000,000 annually as a difference in favor of electric versus steam engine repairs and maintenance.

The total unit cost of electrification will be approximately $40,000 per mile of main line track, which with 12,600 miles to be electrified would cost $500,000,000. In addition, yard and siding trackage would call for $300,000,000 or a total of $800,000,000 This sum will cover the necessary construction and equipment for

the railways beginning with the electric substations and with the driving wheel of their electric motive power.

The electrification above outlined will displace approximately 7,000 steam locomotives, which at salvage value of $22,500 each will credit the electrification estimate with approximately $150,000,000, leaving a net investment of $650,000,000, which taken in connection with the afore-mentioned savings of $90,000,000 per annum would return approximately 14 per cent on the investment.

Regarding other phases of the subject, the report says, in part:

There are approximately 50,000 industrial plants in the zone which either purchase or generate power. The Bureau of the Census is at present compiling the statistics of the 1919 Census of Manufacturers. As soon as the tabulations are completed by the Bureau of the Census, we, in conjunction with experts in the various industries, will analyze and ascertain what possible fuel savings could have been made by the Superpower System in 1919. From the data at hand, a saving of between six and eight millions of tons of coal is indicated. In the anthracite coal mines of Pennsylvania, by means of electrification and the supply of superpower, a conservative estimate based on actual tests shows a saving of 6,500,000 gross tons of anthracite. We are at present preparing estimates on the cost of completely electrifying the anthracite mines.

The data required of the Industrial Division will be ready by May 1, for assembly in its final form.

A large saving of coal can be effected through the more efficient generation of power by the new superpower stations. We find that the average rate of coal consumption for present central station output is 2¾ pounds per kilowatt-hour. Power can be produced in the superpower system at an average rate of 1¾ pounds per kilowatt-hour. The present central station output of coal-generated power within the zone is 8,000,000,000 kilowatt-hours. Therefore, 1 pound saved per kilowatt-hour will conserve 4,000,000 tons of coal annually.

The location of the large superpower stations and their attendant transmission lines is related to the establishment of load centers throughout the superpower zone to which power will be transmitted from them at minimum distance. To date it is indicated that some 20 load centers will be established. By March 1, sufficient data will be at hand to establish these load centers, after which the location of new superpower stations and their interlinking transmission systems can be promptly determined within the zone.

The development of power outside of but for transmission to the zone is being most carefully considered having relation to the St. Lawrence River, other hydroelectric powers and the bituminous coal mines.

A conference with the coal authorities indicates that a fair figure to take for the average price of coal during the period 1919, was $2.90 per ton at the mine, and that during the period from that date to 1930, $3.50 per ton.

With regard to water power for the zone, a summation of the possible outputs from the Potomac, Susquehanna, Delaware, St. Lawrence (American rights), Raquette and the Adirondack powers indicate that for an average year there will be available 12,000,000,000 kilowatt-hours, and for a minimum year 8,360,000,000 kilowatt-hours; the plant capacity being 2,300,000 kilowatts to furnish this amount of energy. It is of interest at this point to state that in 1930 the total power requirement in the superpower zone indicated by projected growth curves will be 48,000,000,000 kilowatt-hours, of which amount the superpower system could supply 36,000,000,000 kilowatt-hours. This, therefore, indicates that the water power supply can be but from 20 to 25 per cent of the total.

I am pleased to be able to say that through the unusual cooperation of the public utilities, the railways, and the industries, the completion of the work will be, after May 1, substantially a matter of computation and tabulation.

Concerning legislative and financial status, the following paragraphs represent the general expression of opinion at the Washington meeting of the advisory board February 18.

Needed Legislation

Legislation should take the form of an act permitting the formation of a corporation authorized to take by eminent domain lands or interests therein necessary or appropriate to the construction, maintenance and operation of lines for the transmission of electric energy. Such legislation may be by a separate act or by an amendment to the Federal Power Commission Law.

As a condition precedent to the formation of such a corporation the proposed incorporators should be required to apply to the Federal Power Commission for a certificate that the project is desirable and is justified in the public interest. This application should be followed by a hearing after due notice to the governors of the states through which condemnation rights are asked. If the certificate is granted the incorporators should be permitted to form a corporation with the usual powers and in addition thereto (subject to the approval of the utility commission of the state where the power is to be exercised), the right to construct, maintain and operate power plants and transmission lines, the right to purchase electrical energy from and sell it to electrical power producing and distributing companies. All of these rights should be subject to the exercise by each state of its full police and taxing power.

Financing

The plan of financing which has been suggested is based on the supposition that the superpower system is in its very nature an extension of present power supply systems, whereby, combining several large plants with present relatively small plants, economy in generation and conservation of natural resources can be secured over that at present attained. Therefore, the vested rights of existing public utility power generating and distributing companies should be protected.

Dependence must be placed on the incentive of private initiative to lower costs and on some form of public regulation of prices to the consumer. The power generated and distributed by the superpower system will finally be distributed to the public by means of existing companies and the economies to the public utility companies which will result must ultimately be reflected in prices to the consumer through the action of present state regulating bodies.

The financial plan in bare outline provides for a superpower company with non-par stock as its only class of security. The public utilities within the Boston-Washington zone to be entitled to subscribe for this stock pro rata, based upon capacity demand and load factor. Stock not taken by these customers of the superpower system to be offered to public subscription.

A contract between the superpower company and a local public service company would be a selling contract or a buying contract, while in many cases both buying and selling of current would be involved. These contracts on which the state regulatory bodies would pass to be adjusted from time to time to meet the progress of the art and changing conditions, whether favorable or unfavorable to costs of operation.

Returns upon the stock of the superpower company should be limited by specific provision to a fair division of the benefits derived from its operation between the investing public and the consumers that will make it possible for the superpower company to come into existence, and at the same time be able to serve the public adequately. New capital is the keystone of the project but the public demand is its foundation. This division of benefits would be attained by a rule under which the customer companies shall participate equally with the stockholders in any distribution at stated intervals, of net earnings in excess of a specified rate of return, which itself should be more liberal than is commonly contained in the idea of public regulation. Thus efficiency in management would be rewarded and the public interest directly served. To secure the participation of the ultimate consumer in this division of benefits, provision should be made that the superpower stock held by any public service company be regarded as representing an extension to its existing station capacity rather than an outside investment security.

Absolute publicity of the superpower company's operations will be an essential condition. Freedom of action should, however, be also sought for this company in order to promote the free flow of capital to this enterprise whose requirements will be large and continually increasing.

The prime object of the superpower plan is a larger supply of cheaper power. The superpower survey looks to the full utilization of all resources and conservation of the country's fuel can not be attained except with the aid of large capital investment. Neither the nation, by coal conservation, nor the individual consumer, by lower rates, can profit by the project, however sound in its engineering and economic phases, unless the conditions of financing are sufficiently attractive to warrant the use of the country's financial resources.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of this Important Application

By Charles W. T. Stuart

VIII. — Sangamo Ampere-Hour Meters

A SANGAMO ampere-hour meter, Fig. 1, is an instrument for measuring ampere-hours. (Current in amperes multiplied by time in hours equals ampere-hours.) The ampere-hour is the unit in which we measure the capacity of a storage battery and therefore the ampere-hour meter is a very useful instrument in car lighting service. It indicates the condition of a battery with respect to state of charge; that is to say, it will indicate that a battery is 20, 30 or 40 per cent charged, and therefore will give a certain percentage of a full discharge. This, however, is indicated in ampere-hours instead of percentage, although the percentage basis is a

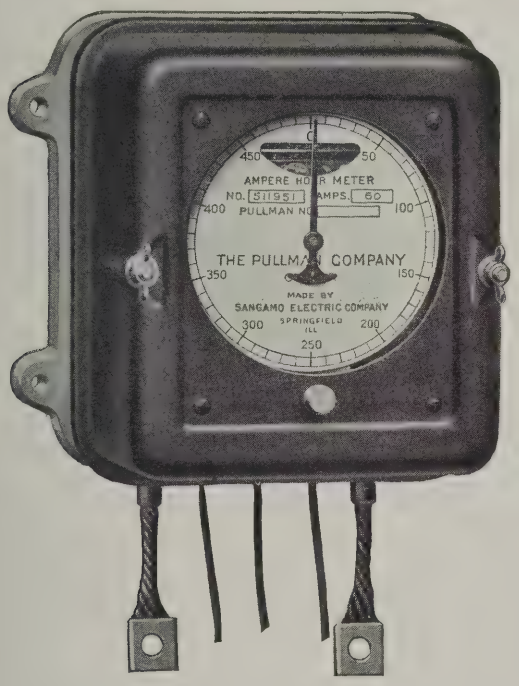


Fig. 1—The Sangamo Ampere-Hour Meter

big help in figuring battery efficiency. It is a well known fact that storage batteries are not one hundred per cent efficient. They will not deliver an amount of current equal to the amount used in the previous charge. For example, the normal discharge rate of a certain lead cell is eight hours at 37.5 amperes, or a total of 8 x 37.5 or 300 ampere-hours. The normal charging rate of this same cell will be 8 hours at 45 amperes or a total of 8 x 45 or 360 ampere-hours. Note that it required 360 ampere-hours to charge the battery, which, in turn, is capable of delivering only 300 ampere-hours. The efficiency in this case will be

$$\frac{300 \text{ of } 100\% \text{ or } 83.3\%}{360}$$

Another example is a type A-8-H Edison cell having a normal capacity of 300 ampere-hours. The normal discharge rate for this cell is 5 hours at 60 amperes or 300 ampere-hours, and the normal charging rate is 7 hours at sixty amperes or 420 ampere-hours. Note in this case the battery requires a 420 ampere-hour charge and delivers only 300 ampere-hours on discharge. The efficiency of this cell is

$$\frac{300 \text{ of } 100\% \text{ or } 71.4\%}{420}$$

It must be remembered that these efficiencies were figured on a normal basis and that the normal efficiency of a battery is affected by a number of factors, one of which is the rate at which the battery is charged and discharged. For instance one car will have a total discharge (lamp load) of only eight amperes while another will have a total discharge (lamp load) of 35 amperes, and both cars equipped with the same size and type of battery. Consequently the efficiency of the same battery will vary on different classes of cars.

The normal efficiency of a battery is also affected by the strength of the electrolyte, condition of the plates, and the nature of the charge and discharge. It would not be reasonale to expect a battery four years old to have the same capacity as a new one. Also, a battery neglected and abused, such as neglected flushing periods, or standing for long periods in a discharged condition, would not have the same efficiency as one of the same age that had received good care.

The nature of charge and discharge is variable. Suppose we compare two similar cars, one operating in an express train with a three hour steady run between station stops, and the other operating in a local train with a ten minute run between stations. The battery on the car operating in the express train will receive a continuous three hour charge, while the battery of the car in the local train receives a ten minute charge and then a two minute discharge, then another ten minute charge and two minute discharge and so on, repeated again and again until the battery receives a charge equal in ampere-hours to the one in the express train. At the end of each run the Sangamo ampere-hour meter on each car will indicate the batteries in the same condition as to their state of charge, but as the charge in each case was of a different nature, they will not have the same efficiency. That is to say, the steady charge has a higher efficiency than the interrupted charge or vice versa. Taking all these characteristics into consideration, one can easily see that it is not a small matter to determine upon the arrival of a car at a railroad terminal the condition of the battery with respect to its state of charge.

The Sangamo ampere-hour meter, however, has been designed, with the addition of new devices, in an effort

to compensate for some of the conditions that affect battery efficiency and today this meter is a very essential part of nearly every car lighting equipment.

Types of Ampere-Hour Meters.—Ampere-hour meters of various types have been used abroad in the sale of electricity, on consumers' circuits for many years, but this practice has not been used in the United States and Canada. Various types have been devised but only four have been developed so as to obtain any practical recognition, namely:

1. Mercury motor meter.
2. Commutator or wound armature type with permanent magnet.
3. Oscillating type meter.
4. Electrolytic type.

The first type is the one that is generally used for car lighting. This type has proved its superiority over the others through a period of more than twenty-five years in England and about ten years in this country. The second and third types are not used to any appreciable extent in storage battery operation. The fourth type, which depends upon the electrolysis of water or

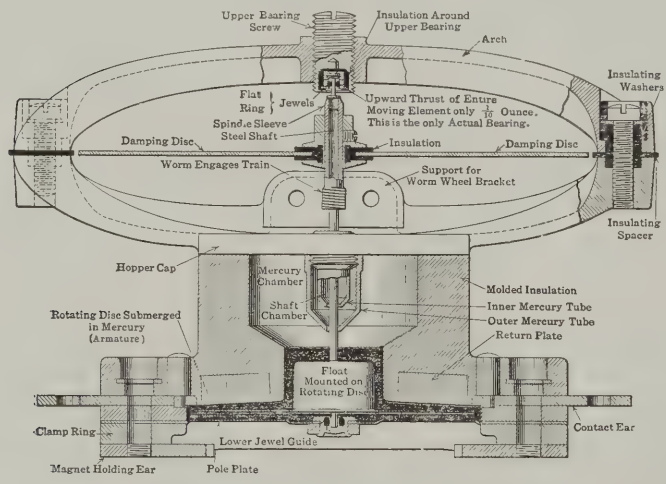


Fig. 2—Cross Section of Mercury Motor of Sangamo Two-Wire, Direct Current Ampere Hour Meter With Recording Mechanism, Field Magnets and Damping Magnets Removed.

salts of mercury, though still used to a considerable extent, is not suitable for storage battery work on account of its being non-reversible.

Principle of Mercury Motor Meter.—The mercury motor type of ampere-hour meter consists essentially of a metallic disc armature submerged in mercury, with suitable contacts embedded in the chamber containing this armature, so that current may be led through the mercury bath and the armature therein, with proper relation to a magnetic field established by a permanent magnet with its poles in proximity to the mercury bath and armature. The current is led into and out from the armature at opposite ends of a diameter of the chamber, and in passing across is subjected to the action of the magnetic fields of opposite polarities, on opposite sides of the center, so that a continual torque is obtained.

The torque exerted on the moving element is proportional to the product of the magnetism and the current through the armature. The magnetic field, being supplied by a permanent magnet, is constant, so that the torque in this meter is directly proportional to the current through it.

On the same shaft with the armature element there is fastened a disc rotating in the field of another permanent magnet which operates as a generator, and the torque required to turn this disc is directly proportional to the speed. Therefore, the speed of the moving element, neglecting fluid and mechanical friction, is proportional to the torque, which in turn is proportional to the current. Therefore, the speed is a measure of the current and each revolution is equivalent to a definite and fixed amount of electricity.

With suitable gear train driven from the shaft carrying the disc armature, the dial attached to the gear train may be made to read in ampere-hours of electricity, that is the product of current and time. This type of ampere-hour meter has many advantages over the other types mentioned above, principally in durability of construction, ability to withstand most severe jarring and vibration without injury to the structure of the meter, simplicity of operation on shunts for large capacities, and adaptability to the various special features required for ampere-hour meters in service with storage batteries.

Construction of Sangamo Ampere-Hour Meters.—In the Sangamo mercury motor ampere-hour meter the principles just described are embodied in the form of a copper disc armature, slotted to increase the rotative effect by guiding the current flow through the armature and between the contacts of the insulating mercury chamber in which the armature is contained. As shown in the cross section, Fig. 2, the armature has a float which gives necessary buoyancy for the entire moving system, including the armature, shaft and damping disc above the mercury chamber. This damping disc is in turn acted upon by permanent magnets, separate from the main driving magnet, so that proper control and adjustment of main speed may be obtained. A large U-shaped permanent magnet surrounds the armature chamber, with its pole pieces at the bottom, the return magnet circuit for the flux set up by this magnet being through a laminated steel ring in the upper part of the armature chamber above the disc.

At the lower end of the shaft a ring jewel guide is used, but as there is no pressure of the moving system downward, no end bearing is required. The shaft passes through an ingenious double tube arrangement by which spilling of mercury is effectually prevented when the meter is turned upside down or on its side. This is a considerable improvement over the former single tube device used in Sangamo meters for the same purpose.

At the top the shaft carries a sleeve with a worm driving the recording train; this sleeve also supports the aluminum damping disc. In the center of the cast iron arch above is carried the upper jewel bearing, consisting of a ring jewel to guide the shaft and an end jewel to receive the very light upward thrust of the entire moving system, amounting to about one-tenth ounce. The upper bearing is adjusted to give a very slight lift to the moving system so that the armature stands practically central in the mercury chamber.

With this construction there is practically no bearing friction on the jewels and any vibration or jar to which the meter is subjected, (which in another construction might seriously damage the pivot and bearing jewels of the moving system) is effectually damped out by the

dash pot action of the armature immersed in mercury. Sangamo ampere-hour meters may therefore be employed in the most severe train lighting service without danger or injury to any part of the motor element, the driving magnets, or the damping magnets.

Storage Battery Efficiency.—The Sangamo ampere-hour meter is used in car lighting service to indicate the condition of the battery with respect to state of charge, and as a storage battery is not a hundred per cent efficient that is, no battery will give out as much current as put into it, it becomes necessary that a meter be so designed that it will automatically allow for the excess of charge over discharge if it is to satisfactorily meet the requirements of service. The efficiency of a battery, that is the ratio of possible discharge to the previous charge, varies with different conditions of use and with the type and condition of battery, so that an ampere-hour meter intended to indicate condition of a battery with respect to charge, should be adapted in each case to the type of battery and particular conditions under which it is to

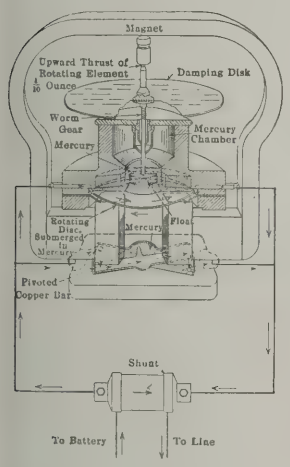


Fig. 3

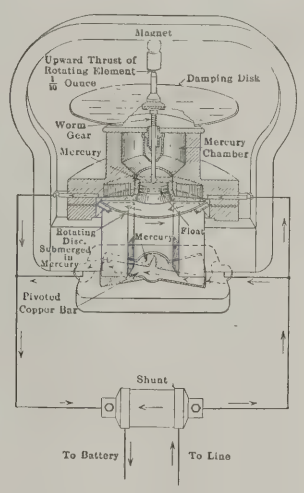


Fig. 4

Fig. 3—Diagram of Meter With New Type Resistor, Showing Position of Resistor Vane on Discharge. Arrows Show Direction of Current Flow.

Fig. 4—Diagram of Meter With Resistor, Showing Position of Vane on Charge.

operate. The following special features serve to adapt Sangamo ampere-hour meters for actual service conditions.

Overcharge Feature.—Any battery whether of the lead or nickel-iron type will require, under the very best conditions, about ten per cent more electricity to be put in on a charge than can be taken out on the next discharge, and under many conditions, thirty per cent more is required. It may be fairly stated as an average condition, that an overcharge of from ten to thirty per cent will be required.

With a simple ampere-hour meter as described above, assuming that a battery is discharged through such meter, properly calibrated, true ampere-hours will be recorded. If on the next succeeding charge the indicator of the meter were simply returned to the point from which it started, the battery would not be fully charged and the indicator would have to continue past the original point by ten to thirty per cent, depending upon the conditions, in order that the battery should be fully charged. This would without a doubt make the meter impracticable. This difficulty is overcome in Sangamo ampere-hour meters by the use of a variable resistor element, and differential shunt or a manual resetting device.

Variable Resistor Element.—The variable resistor element, is most generally used in Sangamo ampere-hour meters to compensate for overcharge. It consists of a narrow copper bar immersed in a mercury filled chamber, similar to the armature chamber of the meter proper, except that the bar, instead of rotating, is limited to a certain angle of swing so that at one position it lies between contacts embedded at opposite ends of the chamber, while at the other end of the swing it is away from the contacts, and the path of current through the resistor lies largely through mercury of relatively high resistance instead of principally through the copper bar. By having this element in parallel with the main armature chamber or measuring element, of a Sangamo ampere-hour meter, either with or without a shunt for large capacities, a different amount of current will pass through the measuring element for a given flow of current in the main circuit, depending upon whether the resistor bar is at the point of minimum or maximum resistance between contacts. By a simple adjustment, the angle of swing may be limited to any desired amount from zero, when no effect will be obtained, to the maximum, giving approximately thirty per cent overcharge. Therefore, by means of the resistor a most satisfactory and easily altered adjustment for overcharge is obtained. The resistor bar swings automatically on reversal of current flow through the meter. This is due to the resistor element being located directly beneath the pole pieces of the driving magnet, so that the current passing through the resistor bar reacts with the leakage field from the pole pieces, causing the bar to swing to one extremity or the other within the chamber, according to the direction of current flow. Therefore, the bar will be at the point of maximum resistance as in Fig. 3 on discharge, while if current be reversed, as shown on the next succeeding charge, it will immediately swing to the point of minimum resistance between contacts as shown in Fig. 4, and will remain there as long as the current continues in the charge direction.

Differential Shunt Feature.—The differential shunt type meter involves a principle of operating for obtaining any desired percentage of overcharge. This meter is used on straight storage cars where the battery is not floated on the line. It can not be used in any system where the generator must supply current to lamps on the battery circuit at the same time it is charging the battery. The arrangement of the differential shunt with the simple ampere-hour meter element is shown in the diagram, Fig. 5. The principle of operation is that a greater drop is obtained from the shunt in a discharge circuit than in the charge circuit so that the meter will run relatively slower on charge, on a given load, than on discharge. By means of suitable bridging connections on the shunts, and a sliding adjustment, it is possible to maintain the meter correct on discharge, and to change the adjustment by any desired percentage slow on charge. With this arrangement of differential shunt, assuming that the indicator of the meter has recorded true ampere-hours discharge, the meter will run slow on charge so that when the indicator has returned to its original position, necessary overcharge will have been given and the

battery will again be full when the hand shows at that point.

Manual Reset.—The simplest means of compensating for overcharge is non-automatic; that is, it depends upon the resetting of the indicator hand by the battery operator. In this case, the simple type of meter, without resistor or differential shunt is used, and the indicator hand is provided with a mechanism accessible from outside the meter cover, by which the hand can be set at any desired point before or after the charging process is started. The resetting device is also very useful on meters having either differential shunt or variable resistor, as it is necessary from time to time to give any storage battery a special overcharge, and in such cases a predetermined amount of charge may be given by simply setting the indicator hand ahead to any desired point by means of the resetting device.

Stop Charge Feature.—With ampere-hour meters in car lighting service it is usually desirable to have some means of automatically stopping the charge when the indicator hand has returned to the full-charge point. For this reason the Sangamo ampere-hour meters for such service have an insulated contact placed at the zero or full-charge point on the dial. When the hand reaches this point a shunt trip circuit breaker may be operated, automatically discontinuing the charge. In addition to the contact at full-charge point, it is sometimes desirable

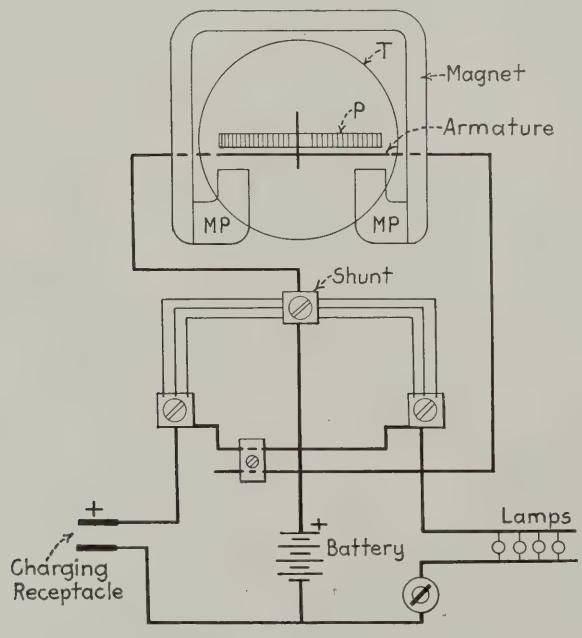


Fig. 5—Circuit Diagram of Differential Shunt Type Sangamo Ampere-Hour Meter

and in many cases necessary, to have one more contact at another point on the dial of an ampere-hour meter to operate relays to discontinue discharge and start a recharging operation. This second contact may be placed at any ampere-hour discharge point on the meter dial.

Method of Increasing Light Load Accuracy and Taking Care of Internal Battery Losses.—As the use of ampere-hour meters became general several years ago in railway train lighting, it was found necessary in many cases to reset the indicator hands of meters, even when equipped with differential shunts or variable resistors, so as to give overcharge quite frequently to compensate for internal loss of a battery when standing idle or for current not registered by a meter at very small fractions of rated load. To compensate for this, a thermo-couple shown in Fig. 6, is used in Sangamo meters. This thermo-couple consists of two pieces of dissimilar metal brazed together, and heated by a fine wire resistance winding connected across the circuit in which the meter is placed, so that a very low difference of potential is set up in the thermo-couple. Having the terminals connected through a suitable adjusting resistance to the motor element of an ampere-hour meter, a current will pass through the armature from the thermo-couple, which, when properly adjusted in volume, will cause a slight continuous rotation of the meter disc, thus recording on

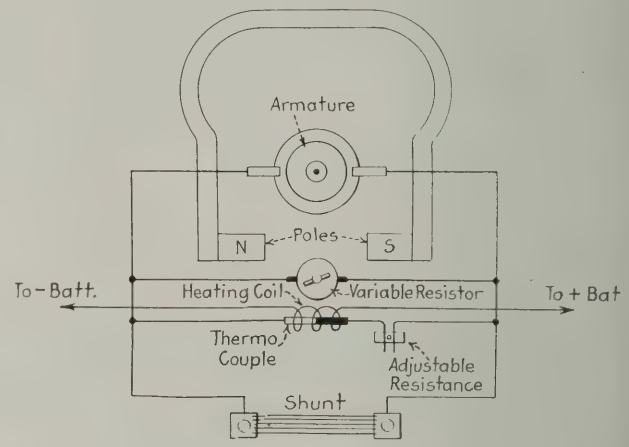


Fig. 6—Thermo-Couple and Resistance Connected in Multiple With Armature Circuit Heating Coil Connected Across Battery Terminals

the dial and compensating for internal loss in a battery standing idle. Aside from this, the least amount of load current passing through a meter with such compensation will be accurately measured as the armature is in rotation without the load current on, and will therefore increase in speed of rotation in direct proportion to the least current flow in a circuit in which the meter may be connected. By using the thermo-couple in a Sangamo ampere-hour meter, the indicator of the meter will be kept in perfect step with the condition of the battery with respect to charge, over very long periods, without periodical overcharge, as would otherwise be required.

Application of Sangamo Ampere-Hour Meters.—The auto base type of Sangamo ampere-hour meter is used with the three general classes of car lighting equipment, namely:

1. Axle generator equipment.
2. Head end generator equipment.
3. Straight storage equipment.

The term auto base was given many years ago when meters of this form were originally brought out for use on electric automobiles. Aside from this, the designation has no special meaning. The auto base meter has an aluminum base for the operating parts, with black enameled metal cover and connections brought out either as back extending studs or bottom connecting cables.

Application with Axle Generator Equipment.—The axle generator equipment includes a generator on each car which is driven from the car axle so as to keep the battery on the car at as nearly full charge as possible, meanwhile the battery carries the load below a certain critical speed. With this equipment the ampere-hour

meter has proved extremely valuable in preventing excessive battery overcharge. This is accomplished by means of the full-charge contact in the ampere-hour meter. As now applied, when the ampere-hour meter hand reaches the full-charge point, it operates through a relay or other equivalent device to change the field strength of the generator so that the charge to the battery is reduced to zero and the battery floats, or is approximately at that point. The battery continues to float while the train is above critical speed, and then after the next stop, charging is resumed until the battery again reaches full-charge

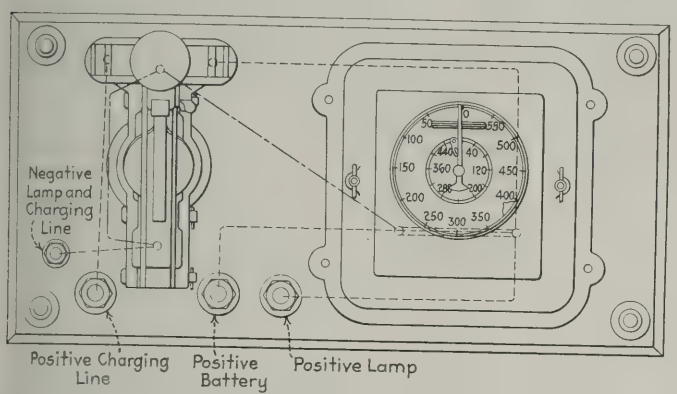


Fig. 7—Control Panel With Meter and Circuit Breaker. Electrical Connections Shown By Dotted Lines

point when the operation repeats, preventing excessive overcharge. There are various modifications in several types of axle generator equipments which may require in individual cases certain changes in the arrangement of the full-charge contact, and with one or two types of equipment a restoring contact is required at a certain point of discharge, so that relays may be operated by the two contacts.

Sangamo Meters with Straight Storage Equipment.—Aside from the application of the Sangamo ampere-hour meter as automatic control of the battery charge with axle equipment as now used on railroad cars in the United States and Canada, they have been used for many years on several well-known railroads having straight storage battery lighting equipment; that is, where the lights are

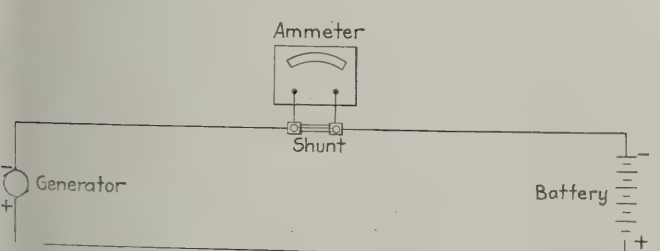


Fig. 8—Method of Connecting An Ammeter in the Main Circuit

supplied by a battery on the car, which is charged at terminal points, but with no generator on the car itself. In this service the meter records total discharge while the battery is carrying the load of lights, fans, etc., on the car, and indicates total charge plus the necessary overcharge when the battery is charged at terminal points. Meters for this service are frequently equipped with Sangamo circuit breakers on a panel arranged for installation in lighting cabinets of the car, as shown in Fig. 7.

Sangamo Meters with Head End Equipment.—With head end equipments, that is where the generator is carried in the baggage car or on the locomotive, it is necessary to use a somewhat different arrangement of meter and relays, if automatic control is desired. On a number of railroads having head end equipments, meters with duplex gear trains are used to keep track of the condition of the battery on each car, but not to give automatic control of the battery charge.

Fundamental Principles of Application.—The fundamental principles in the application of Sangamo meter control may be divided into three general classes, (a) those in which the meter indirectly controls a resistance in series with the generator field; (b) those in which the meter, either directly or indirectly, controls a resistance in series with the voltage controlling solenoid and (c) those in which the meter indirectly controls a resistance in parallel with the generator field.

Fig. 7 shows a Sangamo control panel for use on either straight storage or axle generator cars. With either system the circuit breaker controls the external charging circuit only, that is the charging from a yard plant, and has no connection whatsoever with the charging line from the axle generator.

Other control panels consisting of a circuit breaker and two ampere-hour meters having a rating of ten and sixty amperes respectively are also used. The meter with the ten ampere rating registers the current on discharge, and the one with the sixty ampere rating registers the current on charge. These meters are of the simple

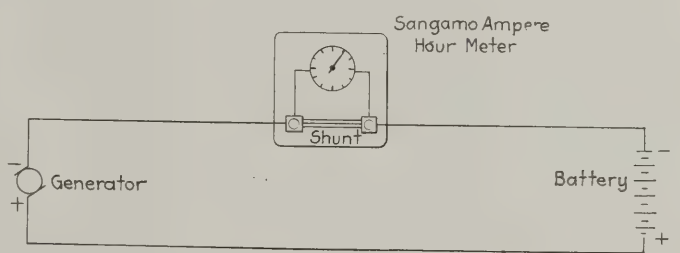


Fig. 9—Method of Connecting a Sangamo Ampere-Hour Meter in the Main Circuit

shunt type and are equipped with the manual resetting device. The circuit breaker controls the charging circuit only. This panel is designed for use in cars having a very small lamp load such as refrigerator cars. The operation of this panel is as follows: assuming a fully charged set of batteries are applied, the pointer of the discharge meter should be set by hand at zero. When necessary to charge the battery the hand of the charge meter should be set to the ampere-hours indicated on the discharge meter, and the circuit breaker closed. As the batteries are charged the hand will rotate counter clockwise and when charge is completed the hand will close the contact at the zero point, opening the circuit breaker and cutting off the charge. If the charge is complete, the needle on the discharge meter should be set by hand at zero or if not complete, at the ampere-hours indicated by the hand of the charge meter.

Sangamo Circuit Breaker.—The Sangamo circuit breaker, Fig. 7, is extremely simple. It contains two sets of contacts, one set for controlling the main battery charging circuit and a smaller set for controlling the breaker shunt coil circuit. The breaker is operated by this shunt coil which is energized by the operation of the zero con-

tact on the Sangamo meter dial. The shunt coil operates the breaker by tripping a latch. This latch when closed will stand such jarring and vibration as is encountered in train operation without allowing the breaker to open and yet as soon as the shunt coil is energized, it opens instantly and positively.

New Quick Break Contact.—The new break contact is a big improvement over the old type of contact. The meter dial hand, instead of simply making a butt contact as it comes around to the zero point, engages a dog which is pivoted and bears against a spring carrying a platinum contact, causing it to make contact with similar platinum point above, thus closing control circuit. After the dial contact has been made and battery charging discontinued, the meter is no longer driven in a charging direction. Accordingly, the contact remains closed until the battery has discharged so that the meter hand moves back to the 50 ampere-hour mark on the dial at which time the meter dial contact is opened instantaneously.

Method of Connecting a Sangamo Ampere-Hour Meter in a Circuit.—Carlighting men use a direct current ammeter in testing axle generator equipment. This instrument indicates the amount of current in amperes that is flowing in the circuit. If the ammeter indicates that the battery is receiving a charging current of forty amperes, and the charge continues for one hour, the battery has received forty times one or forty ampere-hours charge. This is exactly what the ampere-hour meter does, it multiplies current and time, and the product in ampere-hours is indicated by a hand which is moved around a graduated dial.

The direct current ammeter in general use for testing axle generator equipment is of the external shunt type. This type of ammeter is very convenient for this particular work because the shunt can be equipped with blades and inserted in place of the generator fuse, thereby eliminating the necessity of disconnecting wires from the apparatus. Fig. 8 shows the method of connecting a direct current ammeter to measure the current in the generator and battery circuit. The shunt is inserted in series with the circuit and two flexible wires connect the instrument directly across the shunt.

A Sangamo ampere-hour meter is connected in such a circuit in like manner. The shunt is connected in series with the circuit and the various meter circuits are connected by small conductors across the shunt as shown in Fig. 9. The indicating mechanism of an ampere-hour meter is different from that of the ammeter in that it contains a means for revolving a train of gears which in turn moves a hand over a graduated dial.

Proposed Power Development on the Delaware River

ANNOUNCEMENT of a proposed plan to develop about 500,000 kw. in water power on the Delaware River, at a total cost estimated at $200,000,000, has been made by Paul T. Brady of the Westinghouse Electric & Manufacturing Company. Active work will be commenced as soon as authorization is received from the Federal Water Power Commission. The plan calls for the construction of four dams, at or near Belvedere, Bushkill, Shohola and Butler's Rift, with an average head of 80 ft. The total power capacity of these four dams is estimated at about 500,000 kw. at normal high water. In addition a steam-power plant with a capacity of 100,000 kw. will be erected somewhere in New Jersey in order to supplement the hydro-electric plants during seasons of low water.

Power will be sold wholesale in large blocks in New Jersey, eastern Pennsylvania and southern New York, though it is believed at this time that New Jersey will take the major part of the total output. If present plans are carried out the steam power plant and two of the hydro plants will be in operation by January 1, 1923.

Mr. Brady has applications covering all of the desirable water-power sites in the hands of the Federal Water Power Commission, where they are grouped under the title of Project No. 22. He is at present working in an individual capacity, but will turn the whole proposition over to a corporation as soon as the necessary preliminaries are settled. Associated with Mr. Brady are Duncan, Young & Company, the L. B. Stillwell Engineering Company and the engineers of the Westinghouse Electric & Manufacturing Company.—*Electrical World.*

Standardization of Insulated Wires and Cables

A CONFERENCE on the standardization of insulated wires and cables was held in New York in the early part of February. The conference, which was called by the American Engineering Standards Committee at the instance of the American Railway Engineering Association, was attended by representatives of fourteen national organizations.

After a thorough discussion of the many considerations involved, it was unanimously decided that "The unification of specifications for wires and cables for other than telephone and telegraph use should be undertaken under one general plan, covering substantially all the more important uses." It was agreed that work on the following should be included:

Conductor, quality, stranding, sizes.
Rubber insulation.
Varnished cloth insulation.
Impregnated paper insulation.
Magnet wire (including enamel, cotton and silk insulation).
Fibrous coverings (including asbestos).
Sheaths.
Armor.
Standard make-ups.

Nearly a dozen organizations now have important publications on the subject, and it was agreed that the proposed work should be a unification of the specifications and standards already in existence, rather than an attempt to formulate entirely new standards except in fields not already covered.

It was the consensus of opinion that, in order to promote export trade, it would be desirable to have all the American wire and cable standards assembled in a single book. This form of publication, while giving due credit to the participating organizations would appear to foreign wire and cable purchasers as a complete book of American Standards, rather than as the standards of societies comparatively unknown

abroad. This has been done in a very thorough way by the Germans and to a considerable extent by the British, thus placing Americans at a decided disadvantage in foreign trade. It was agreed that if such a book were prepared and given proper publicity in foreign countries, it would remove one of the greatest difficulties under which American manufacturers are now laboring in developing export trade.

The proposed work will be carried out under the auspices and rules of procedure of the American Engineering Standards Committee.

A High Voltage Wire Crossing

THE number of wire crossings where electrified steam railroads cross lower voltage street car lines are relatively few at the present time. The ruggedness of their construction, however, is of utmost importance and the illustration shows one scheme by which such a wire crossing has been successfully accomplished. The line supported by the catenary is 11,000 volt a.c., while the street car trolley is the usual 550 to 600 d.c.

The 11,000-volt trolley wire, *A*, terminates in a flat iron strap, *C*, on either side of which are bolted two strips of hardwood approximately 8 ft. long. To the other end of these wooden strips, *D*, are bolted two pieces of heavy strap iron, *E*, the angle of which is determined by the crossing angle of the two roads. To the angular strap, *E*, is bolted the channel iron, *B*, through which the 550-volt d.c. trolley wire runs across the high voltage catenary construction of the electrified line.

The section of trolley line, which is attached to the channel iron and which extends but a few feet beyond the end of the channel iron is normally dead and is only energized when the street car is actually passing over the crossing. This short dead section may be energized from either side of the crossing, or from one side only, by means of a suitable switch mounted upon a pole. Such a switch is shown at *F*. It will be seen that one end of it is hinged on the underside of the crossarm and it is to this movable part that the dead section of the trolley line is connected. The live contact of the switch may also be mounted upon the underside of the crossarm, but under normal conditions it is evident that the trolley feeder does not supply energy to the section of wire over the crossing. Whenever a trolley car arrives at this point the conductor raises the handle *G*, which communicates its motion to the switch blade *F*, through the long wooden rod, *H*. As long as the handle *G* is held up the switch will remain closed, the usual practice in this respect being to hold the handle up until the trolley car has cleared the crossing and is again upon the live section on the opposite side.

The entire weight of this overhead construction is supported by the 11,000-volt catenary, which is sufficiently strong to bear the weight with an ample factor of safety. Such a crossing as this is used on the Boston & Maine Railroad at North Adams, Mass., where that line crosses the State street car line. Dimensions have been omitted from this sketch but the construction features are sufficiently plain to enable one to design a similar crossing with material of such size and strength as may be desired.

The wire crossing used on the Boston & Maine has proved to be satisfactory in every respect. As the electric locomotive passes over the street car line it is necessary to lower the pantagraph during the time the locomotive is on the crossing. This, however, has not proved to be any serious inconvenience, as the distance between the two pantagraph shoes on the locomotive is sufficiently great to span the width of the dead section so that it is not possible for any locomotive to stall at this point on account of its inability to draw power from its trolley supply.

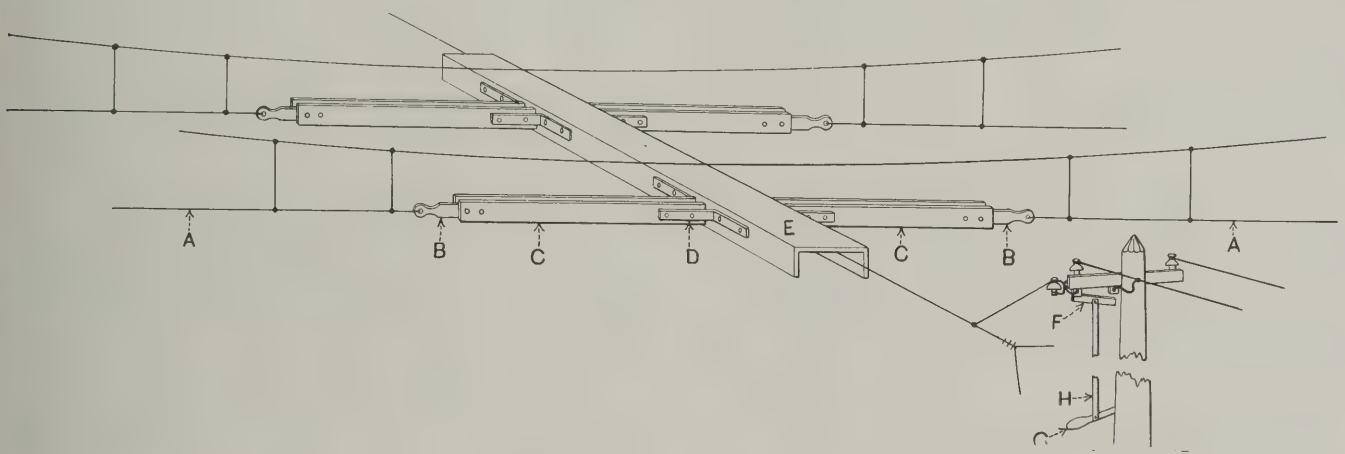


Diagram of High Voltage Wire Crossing Showing One Method of Accomplishing the Desired Result

The Use of the Magnetic Compass for Testing

By W. S. Henry
Service Engineer, General Railway Signal Co.

THE compass test is based upon the fact that magnetic lines of force emanating from different sources in close proximity tend to become parallel with each other if the lines of force from the two sources conflict as to direction. The compass needle is a hardened piece of steel that has been permanently magnetized and when not under the influence of magnetic forces other than the earth, it points north and south. Its lines of force are affected by those of the earth so as to cause the needle to assume a posi-

tion where the lines of force from the two sources are parallel.

How the Current in a Wire Affects the Needle

Current flowing in a wire sets up a magnet field around the wire, with the lines of force in imaginary circles, the planes of which are at right angles to the length of the wire. Therefore, if a compass is held close to this wire, and the wire length is north and south, current flowing in the wire will swing the compass needle east and west. Upon interrupting the flow of current in this wire, the needle will swing back to its former position, north and south.

This performance makes it possible to identify a wire carrying current if the current is interrupted at frequent, regular intervals. If an uninterrupted current prevails, there would be no way of determining when the needle was influenced from another source, since other influences may easily cause a considerable movement of the needle out of its usual north and south position.

Advantage may be taken of the facts mentioned in order to locate grounded circuits or breakdowns in wire insulation. Assuming that such a condition existed, it is an easy matter to find the trouble by making tests with a compass on each wire until the trouble is located.

Using the Compass Test

In some wiring systems it is the practice to connect permanently one side of all functions to the negative side of the source of power, with the other wires involved in the circuits for the operation of the functions, either connected to the positive or to the negative, depending upon the position of the operating connections after the function or functions have operated.

If some part of the system, which is permanently connected to negative, becomes grounded, an intermittent current can be established through the fault and over the return wire to negative battery, by attaching one wire to positive and another wire to ground (such as a city water pipe or a track rail) and then intermittently touching the ends of these wires together. This positive current passes to the ground and searches out the spots where defective insulation makes it possible for it to leave the ground and return on the wire or wires connected to the negative side of the source of power. In this case, if a compass is held close to the wires with the needle parallel with them it will be an easy matter to identify which wire has the faulty insulation. Where common wires are used, the intermittent current will usually be found returning to negative on some one of the several common wires which are ordinarily employed.

In using the compass it is convenient to test at points such as junction boxes, or at branches. Tests conducted in this way will show whether the ground is still farther away, or whether it has been passed. When the compass needle deflects at one location but not at another location close by, the faulty insulation will usually be found between the locations at which the tests were made.

Reason for Intermittent Current

The absence of needle deflection is depended upon to identify the location of the fault. On this account it is important that the one making and breaking the test circuit, do so in a clock-like regularity, keeping constantly at it without intermission, until permitted to stop by the observer making the tests.

It is best to make the positive connection with an ammeter in the circuit to indicate for each current impulse, so that the one interrupting the current may watch the ammeter needle and govern his action in making and breaking the circuit. A break should occur as soon as the current reaches its maximum value, and the circuit should again be closed as soon as the ammeter drops back. This will insure about the right sort of current impulse and will avoid irritation of the eyes, which results if one watches the arc while performing this work. When starting the test, the maximum current to ground should be observed and if this is more than six or seven amperes, a resistance should be placed in the circuit to the ground connection to limit the current to not more than this amount nor less than two amperes.

How to Use Compass for Wires in Any Direction

The compass needle usually points north and south, but the wires may run in any direction. The difficulty of having the needle parallel with the wires, regardless of their direction, is overcome by employing a magnetized knife blade to attract the compass needle to any desired position. Care must be exercised to keep the knife blade as far away from the compass needle as possible and yet secure the necessary needle position, otherwise the knife blade may attract the needle so strongly that the magnetism due to current in the wire may not cause it to swing. Where wires are vertical and cannot be moved to a horizontal position, test can be made with the compass by influencing the needle to point directly toward the center of the wire. However, the horizontal position of the wire is more advantageous for the compass test.

A compass having a needle not more than 3/8 in. in length is recommended for this work, as it starts easily under the influence of a weak magnetic field and comes to rest quickly. The bearing of the compass needle should be so constructed that slight tipping of the compass will not cause the needle to bind.

Difficult Cases to Test Out

Sometimes some difficulty may be experienced in locating the wire over which the intermittent current is returning to negative when it does not appear on any of the common wires. Always bear in mind that whatever current enters the earth from positive must return to negative over some wire that reaches the faulty insulation. Therefore, the search should be continued until such wires are located and the defective insulation found. After it has been determined which function is in trouble, it is a simple matter to correct it or to temporarily isolate it, so that the testing may continue.

This scheme of testing, when one has acquired a reasonable amount of experience, produces results in

an hour or two that would probably take as many days if one endeavored to locate grounded devices by disconnecting each one for checking the integrity of the insulation.

Advantages and Cost of Railroad Electrification

A MEETING of the Electrical Section of the Franklin Institute was held in Philadelphia, Pa., on February 24, which was addressed by A. H. Armstrong, of the General Electric Company. Mr. Armstrong called electrification an economic necessity and spoke of the need for developing railroad facilities. He said that it is a matter of grave national concern properly to diagnose the true character of the ailment affecting our transportation system, and to prescribe the treatment of greatest promise for its future recovery. He enlarged on the subject of how electric operation could best be used to meet future railroad requirements and told of what had already been accomplished.

In summing up his paper, Mr. Armstrong said that electrified terminals in large cities would revolutionize present steam locomotive practice and not only effect economies in operation, but greatly stimulate traffic by introducing radical improvements and facilities. With no immediate prospect in sight for any material reduction in the price of labor, its output must be increased, and electric operation has demonstrated its effectiveness in this direction. In addition, locomotive division points may be indefinitely extended. All of these improvements in the electrified property will cost large sums of money, although in some items of operating expense, such as fuel, crews and maintenance, direct savings are effected of such magnitude as to show a reasonable return upon new capital charges incurred. The argument for electrification, however, is built upon a broader foundation than a direct return upon the investment. It has to do with the vital question of the future growth of our transportation system and its effect upon our national prosperity. The conditions which prevail today in the transportation business should not be taken as a criterion upon which to base future requirements.

In answer to several questions put to Mr. Armstrong relating to electrification costs and mileages, he said that the original 440-mile electrification on the Chicago, Milwaukee & St. Paul cost about $13,000,000. This included freight and passenger and two switching locomotives. This, he said, figures out at about $28,000 per route-mile or $18,000 to $19,000 per single-track mile. The freight and passenger locomotives cost about $130,000 each, and they replaced 112 steam locomotives, worth about the same in total as the electrics; hence the items of locomotive costs about offset each other. The last 220-mile electrification on this road cost more, having been carried out during war time, the increase being, roughly, about 50 per cent.

The White House in Washington is one of the most intricately equipped electrical mansions in the world. There are more than 170 miles of wires, providing 3,000 incandescent lights and a bell and private telephone system for the exclusive use of the President and his family.

Quebec Railroads Should Be Electrified

H. E. Weyman, manager, Levis County Railway of Quebec, in an address given recently before the Rotary Club, Quebec, urged the electrification of Quebec railroads. He said that due largely to the high cost of coal, Canada would at some time in the near future have to decide upon some comprehensive plan for the development of its water power and for the electrification of its railroads. In central Canada, and especially in the Province of Quebec, he said, there are no coal deposits, but nature has compensated for this by providing enormous water power. Comparatively few of these water power sites have been developed to any great extent, while large sums of money are paid out in the purchase of coal from outside the country. It was his contention that plenty of data is available on the subject of electric operation and that electrification was often desirable even in countries which have large coal deposits. He cited operating costs on the Chicago, Milwaukee & St. Paul in an effort to show how Canadian railroads could effect a great economy by similar operation.

Mr. Weyman laid particular stress on the cost of hauling non-revenue coal and on the low cost at which electric power could be produced. Steam locomotives, he said, in the Province of Quebec haul about 15,000,000,000 ton-miles of freight per year. This requires something more than 2,250,000 tons of coal per year, costing from eight dollars to ten dollars per ton, making a total coal bill of from $14,000,000 to $15,000,000. This coal is purchased outside of the province and has to be hauled an average distance of 400 miles from the mines, involving about 700,000,000 ton-miles of non-revenue haulage, or five per cent of the total ton-mile haulage per year. He contended that about 720,000,000 kw. hr. would be sufficient to operate the railroads annually in the zone mentioned, and said that a power plant capacity of 100,000 kw. would be sufficient to generate this power. There are already in the province, water power plants with an aggregate capacity of 300,000 kw. He estimated that the cost of power for electric operation would be about $7,000,000 as against twice that amount now spent for coal, and that the saving due to elimination of non-revenue haulage would effect an additional annual saving of about $1,000,000.

Mr. Weyman made the broad statement that all new railroads to be constructed in the future should be, not only for their own but for their country's sake, operated by electricity.

One of the Electric Locomotives Used on the Gotthard Line of the Swiss Federal Railways

THE INTERCHANGE

Device for Calibrating Voltmeters

The voltmeter is a very essential instrument in train lighting service because the voltage test is the only practical means of ascertaining the condition of a storage battery on a car, with respect to its state of charge, while operating in railroad service. These instruments are very delicate and easily thrown out of adjustment; therefore it is necessary to have some means of checking them at regular intervals with a standard voltmeter.

A device for calibrating voltmeters is shown in the wiring diagram below. It consists of a sliding contact tube rheostat, a standard voltmeter, two pole single throw knife switch, and a pilot lamp.

The basis of the rheostat is a thin metal tube, coated with enamel, and about which the resistance wire is wound. This tubular unit is mounted on two substantial iron supporting feet, each with two screw holes. Parallel to the longitudinal axis of the tube a triangular rod is fixed, along which the regulating slider moves. The slider carries an effective brush device, consisting of a number of laminations and making reliable contact with the resistance wire. The resistance wire is made from a special resistance alloy. Bare wire is used and is coated with

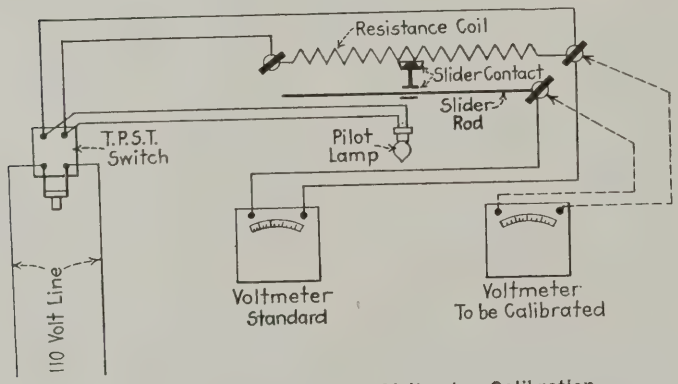


Diagram of Wiring Used for Voltmeter Calibration

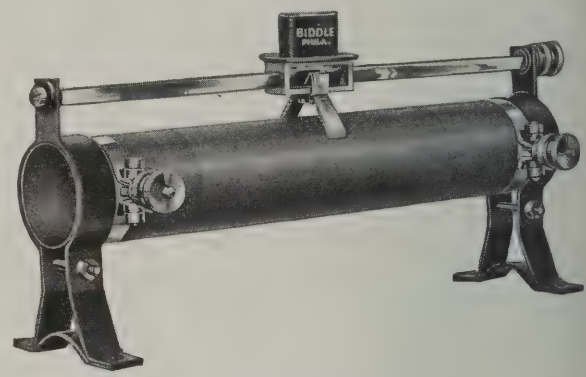
a thin film of oxide, which affords sufficient insulation to overcome the small potential difference between adjacent turns. Under these conditions, no space between turns is necessary, and the entire surface of the tube can be used, thereby greatly increasing the capacity for given physical dimensions. The tube is 2 in. in diameter and 12 in. long. The resistance coil has a resistance of 1,020 ohms and a carrying capacity of .6 ampere.

Three double binding post terminals are provided, one attached to the slider rod, and one at each end of the resistance wire.

The resistance coil is connected directly across the source of supply, and the standard voltmeter is connected across the source of supply in parallel with a portion of the resistance. The value of this resistance is determined by the location of the sliding contact. By the use of this device a voltmeter may be calibrated with the standard meter over its entire scale by connecting it in multiple with the standard meter, and slowly moving the slider contact along the slider rod of the calibrating device.

The pilot lamp is used both as a pilot and to give illumination for calibrating.

At one large railroad terminal where this device is in



Resistance Coil With Sliding Contact

use, there are twelve voltmeters constantly in use takin voltage tests of the batteries on the cars and each inspecto is obliged to check his meter at least twice a day, that i before starting the morning and afternoon periods re spectively.

This device is a big factor in the safe and economica operation of a car lighting department, as it will eliminat waste of current in overcharging batteries and also pre vent the lighting failures which would be the result if th voltmeters were not properly calibrated.

Page the Electrician

"Hello, Mr. Givney?" — "This is George talking. wish you would send down your shop electrician, I've g a hoist here in the ice house that has gone plumb loc Every time I start her she goes to the bottom of the sha first and then comse back up. The motor runs the opp site way each time.—No, sir, I haven't broken Rule All the other fellows have seen it too.—Yes, I wish you get him down here as soon as possible, it isn't handy use any of the other hoists where we're working."

That is what the ice house foreman said and when the electrician got down to the job he found that was just the way it worked. The outfit consisted of a small 3-phase, squirrel cage motor with a solenoid brake connected through a single reduction gear to a drum. A single cable winding up on the drum raised the hoist. The motor was started by throwing it directly on the line. Under normal operating conditions the hoist was raised to any desired level by closing the switch and lowered by pulling on a rope which released the solenoid brake mechanically.

Now they were taking ice from an ice house about half full of ice and raising it to the loading platform from which it was loaded into the top of the refrigerator cars. The hoist was lowered to the desired position by releasing the brake and there loaded with several pieces of ice. The switch was then closed, but instead of going up, the hoist went down. It went to the bottom of the shaft and then came back up, the cable winding in the reverse of the usual direction. When the switch was pulled the motor stopped as usual.

If, however, a poor stop was made and it was necessary to raise the hoist a few inches to get it level with the landing, when the switch was closed the hoist would again go to the bottom of the shaft and come back up, this time winding the cable in the right direction.

It had the electrician stumped for a time but after looking over the outfit he found one fuse blown, a simple reason for a seemingly complicated result. The brake solenoid had a single coil which happened to be connected to the phase that was still live. When the switch was closed, the brake released, but as only single phase current was applied to the motor it had no starting torque and the hoist started to fall; it fell until it had brought the motor up to synchronous speed in the reverse direction. A single phase motor doesn't care which direction it runs in if means are provided to first bring it up to speed, so when the hoist brought the motor up to speed it fell into step as a single phase motor and continued to run in the reverse direction, first unwinding all the cable and then winding it up in the reverse direction until the switch was pulled, cutting off the power and allowing the brake springs to apply the brake as usual. The next time the switch was closed the operation was the same except that the motor was started in the opposite direction, due to the cable being wound up backward. A new fuse corrected all the trouble.

Covering Property of Paint

One pound of ready-mixed paint, when thinned, will cover about two square yards of first coat, three yards of second, and four yards of each subsequent coat; or one and three-eighths pounds to the square yard will be required for four coats and one and five-eighths pounds for five coats.

"I am not much of a mathematician," said Carelessness, "but I can *add* to your troubles, I can *subtract* from your earnings, I can *multiply* your aches and pains, and I can *divide* your attention. I can take *interest* from your work and *discount* your chances for safety.—*The Center Punch.*

A Possible Chance

The college graduate was looking for a position of some sort. Entering an office, he asked to see the manager, and while waiting he said to the office boy:

"Do you suppose there is any opening here for a college graduate?"

"Dere will be," was the reply, "if de boss don't raise me salary to t'ree dollars a week, by tomorrow night."—*The Santa Fe Magazine.*

Osculatory

The gob was on shore-leave and happy because he had found a girl as affectionate as he. His joy was dimmed, however, for a bluecoat had forbidden spooning in the park, and his girl had tabooed it in the streets. But life took a new turn when he saw a man kiss his wife farewell in front of the Pennsylvania Station, New York. He rushed his girl toward a crowd hurrying toward the Philadelphia express, and bade her a fond farewell. When the crowd thinned, they joined a throng for Washington, and repeated the act. They repeated it again before the Chicago train.

This was too much for a colored porter who had been watching. He stepped up to the gob. "Boss," he said, "why don't you go downstairs and try the Long Island Station? Dem local trains am a-leaving mos' all de time!" —*Everybody's.*

Fare, Please!

"Fare, please! Fare!"

The passenger gave no heed.

"Fare, please!"

Still the passenger was oblivious.

"By the ejaculatory term 'Fare,'" said the conductor. "I imply no reference to the state of the weather, the complexion of the admirable blond you observe in the contiguous seat nor even to the quality of the service vouchsafed by this philanthropic corporation. I merely allude in a manner perhaps lacking in delicacy but not in conciseness to the monetary obligation set up by your presence in this car and suggest that you liquidate."

At this point the passenger emerged from his trance.—*London Tit-Bits.*

Upper and Lower

"Let me have sleeping accommodations on the train to Ottawa," I said to the man at the window, who didn't seem at all concerned whether I took the trip or stayed at home.

"For a single passenger?" he finally said.

"No," I replied, "I'm married but I'm not taking anybody with me. A single shelf will answer."

"Upper or lower?" he asked.

"What's the difference?" I inquired.

"A difference of fifty cents," came the answer.

"Our prices to Ottawa are $1.50 and $2.00."

"You understand of course," exclaimed the agent, "the lower is higher than the upper. The higher price is for the lower berth. If you want it lower you'll have to go higher. We sell the upper lower than the lower. It didn't

used to be so, but we found everybody wanted the lower. In other words the higher the fewer."

"Why do they all prefer the lower?" I broke in.

"On accounts of its convenience," he replied. "Most persons don't like the upper, although it's lower, on account of it being higher, and because when you occupy an upper you have to get up to go to bed, and then get down when you get up. I would advise you to take the lower, although it's higher than the upper, for the reason I have stated, that the upper is lower than the lower because it is higher. You can have the lower if you pay higher; but if you are willing to go higher it will be lower."—*Set Square, Toronto.*

The Man Who Fancied

There was a man who fancied
By driving good and fast,
He would get his car across the track
Before the train came past.
He would miss the engine by an inch,
He would make the train crew sore.
There was a man who fancied this;
He isn't any more.

There was a wise old switchman,
Expert at coupling cars,
He used his feet to push in place
The knuckles and draw bars.
He did this for many years,
He thought it was great fun.
He had two feet to push them with;
He now has only one.

Bill Jones on the repair track,
He fancied he could do,
A little work beneath the car
Without his flag of blue.
Well, yes, he did it many times,
In spite of rule or warning,
One day the engine hit the car;
Bill's wife is now in mourning.

Jim was a nimble kid,
He lived nearby the track;
He jumped each train as they went up
And off as they came back.
You couldn't warn Jim,
Jim knew best.
He was in no danger,
His tombstone reads, "At Rest."

Between the rails of the double track,
Mike smoked his pipe of clay,
As 37 with red ball freight
Sped noisily on its way.
It would take four steps to clear the track,
Those steps Mike did not take,
Number four approached unheard,
Result,—an Irish wake.—*Santa Fe Magazine.*

Culture is not sufficiently herculean in strength to develop despite prejudices, but because of them is circumscribed, limited, and sometimes squelched beyond recognition.

It's Up to You

If you want to work in the kind of shop
Like the kind of shop you'd like,
You needn't slip your clothes in a grip
And start on a long, long hike.
You'll only find what you've left behind,
For there's nothing that's really new,
It's a knock at yourself when you knock your shop,
It isn't your shop, it's you. —*Reo Spirit.*

Study Men

Some men have within them that which always spurs them on while some need artificial initiative, outside encouragement.

Some men exert themselves under stern discipline; some respond only to a gentle rein.

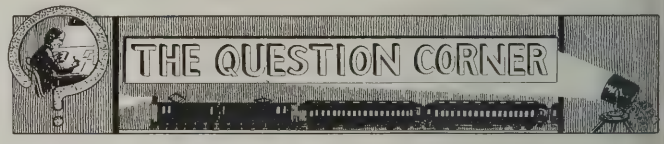
Some men need driving; some coaxing. Some need the spur; some the sugar lump.

Some men do their best with work piled shoulder high; some men must have it given them a piece at a time.

Some men thrive on discouragement; some cannot work without cheerfulness.

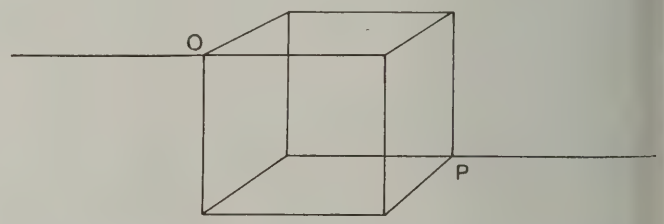
Study men—the men over you, under you, around you.

Study them and learn how to get from each the best that is in him.—*The Chair Man.*



The question of resistance in parallel circuits is one which generally interests electricians able to grasp the fundamental principles involved. Not all problems of this nature are simple and occasionally one comes up that taxes us to the utmost to arrive at a solution. The accompanying diagram presents a problem involving parallel circuits which calls for more than an ordinary amount of thought.

Each edge of the cube shown is composed of a piece of wire having a resistance of 1 ohm. The problem consists of finding the joint resistance of the several paths, between any two diagonally opposite points of the wire cube, as between *O* and *P*. The solution is not the most difficult thing in the world but in fairness it must be said there are problems in parallel resistance that are simpler. Anyone who thinks he can find the correct answer to this question should send in his solution. It may be there are more ways of solving the problem than one. Next month we will publish the correct solution, but don't wait till then; send in your answer now.



If each line in the cube represents a wire with a resistance of 1 ohm, what will be the resistance between O and R.

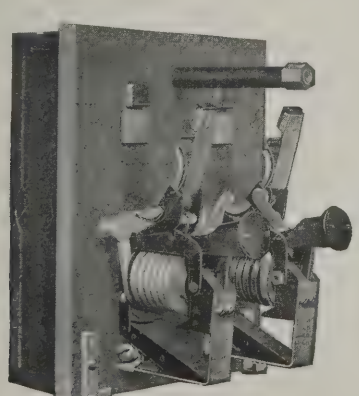
NEW DEVICES

A Two-Pole Circuit Breaker

A new type of circuit breaker having two individually operated contact arms is being marketed under the trade name of U-Re-Lite by the Cutter Company, Philadelphia, Pa. The unique feature of the U-Re-Lite is the two

Circuit Breaker Enclosed Showing Resetting and Hand Tripping Devices

single pole I-T-E circuit breakers which are so designed that after one pole is closed it is free to respond and instantly opens the circuit should the other one be closed against an overload or short circuit. After the circuit is



Interior View Showing the Two Separate I-T-E Breakers

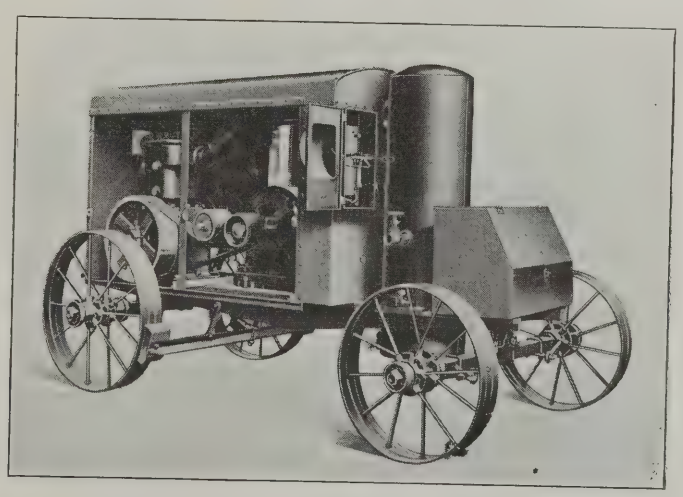
established, when actuated by overload or when tripped by hand, both sides of the circuit are opened simultaneously. Each pole is closed by a slight turn of the handle which is seen projecting above and below the tripping knob. Both poles of the breaker can be quickly reset by simply turning the handle first to the left and then to the right.

The box is made of steel plate of ample strength and rigidity. The exterior is finished in black enamel baked on, and the interior is so insulated that any possible arcing is rendered harmless, and the coming into contact with live parts prevented.

The circuit breaker is made in capacities of 2, 5, 10, 15, 20, 30, 45 and 60 amperes, and is adjustable 33 1/3 per cent below to 50 per cent above its ampere rating as shown on the name dial plate.

Portable Air Compressors

It is often desirable to have a supply of compressed air at outlying points to which it is not economical to extend the yard or shop air lines. The Ingersoll-Rand Company, New York, has designed a compressor to meet these requirements, known as The Imperial Portable



Motor-Driven Portable Air Compressor

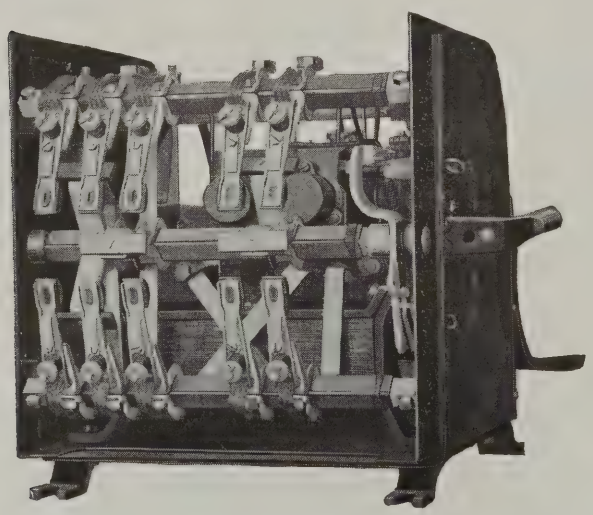
Compressor. For places where electric power is available, the compressor is equipped for motor operation. The unit is of 118 cu. ft. capacity and weighs approximately 4,450 lb., depending upon the weight of the motor. For places where electric power is not available, the equipment is supplied with gasolene power. For gaso-

lene power, these units are driven by tractor type gasolene motors and are built in three sizes, with capacities of 45, 118 and 210 cu. ft. per minute. Both the motor and gasolene units are of all-steel construction. Light steel doors, easily removed, and a sheet steel canopy completely house the entire unit, protecting it from the weather and preventing undue deterioration from rust.

Either an alternating or direct current motor can be furnished and a suitable intake unloader is provided, assuring efficient regulation. In any case, the motor control is in accordance with standard practice and specifications covering the type of motor used. Additional equipment includes an air receiver, safety valve, drain valve, pressure gage and service valves, to which air hose lines may be connected.

New Auto-Transformer Starter

The engineering department of The Cutler-Hammer Mfg. Co. of Milwaukee has devised an auto-transformer starter of unusually rigid construction to meet the severe requirements of the large industrial plant and mine, as well as that of the small mill and factory. The simple steel construction—using no wood or castings whatsoever—the absence of flexible moving leads, and the ease of inspection of the contacts and adjustments of the relays, enable this starter to give continuous and satisfactory service at a low upkeep cost. This starter, which is shown in the illustrations, consists of two auto-transformers, commutating mechanism, low voltage release and duplex overload relay, all enclosed in a sheet metal



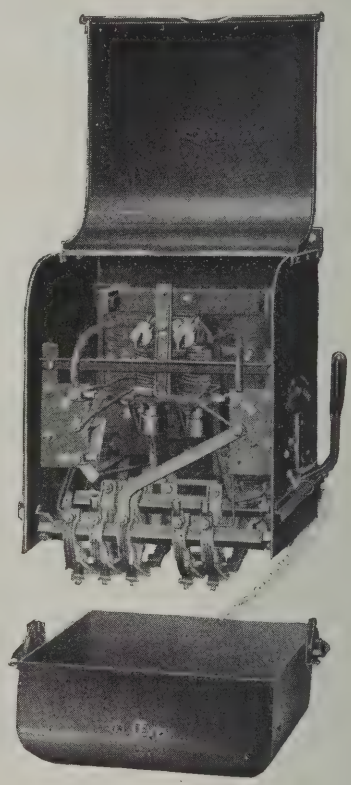
Under View of Starter Showing Finger Construction and Arrangement

case with the operating lever outside. The case is strongly reinforced with angle iron, and has a hinged cover which can be lifted to expose the transformers and relay. The transformers and case are carried directly on the supporting brackets and may be readily mounted on the wall, switchboard, or any post or pedestal.

The starter is operated by moving the operating lever forward to the starting position and then backward to the running position, where it is held in place by the low-voltage mechanism. Interlocks prevent moving the lever directly to the running position. If released in the first or starting position, the lever i returned to neutral by a spring. Locked in the neutra position it prevents unauthorized operation.

Two auto-transformers connected in open delta ar used for both two and three phase service. Th special construction of the transformer core allow either coil to be easily and quickly replaced. Eac coil is provided with three accessible taps which giv 50, 65 and 80 per cent of full line voltage.

The low-voltage mechanism is mounted inside th case on the right-hand side. A wire from the arma



Interior View of Starter With Oil Tank Lowered and Cover Thrown Back

ture of the release coil extends through the case nea the operating handle and is bent to form a hook, slight pull on which releases the starter and return the handle to neutral. Remote control of stoppin may be obtained by inserting one or more normall closed pushbutton switches in the low-voltage cir cuit. Any button releases the starter mechanism.

A duplex overload relay with a true inverse tim limit movement is mounted inside the case on th transformer assembly in such a position that adjust ments for time and current values can be readil made. This duplex relay is equivalent to two over load relays, each in series with one of two phases. Th Underwriters' rules do not require the installation of disconnecting knife switch or circuit breaker ahead o this starter when thus equipped, because the starte completely disconnects the motor from the suppl line when released by an overload.

These starters are made in various sizes for th operation of two or three phase induction motor rated between 5 and 100 hp. on standard commercia voltages between 110 and 2,200 and at frequencies o 60, 50, 40, 33 and 25 cycles per second.

General News Section

The Cutler-Hammer Manufacturing Company, Milaukee, Wis., announces the opening of a St. Louis office the Railway Exchange building, in charge of Harold hillips, formerly of the engineering department of hicago and later office manager of the Chicago office.

The General Electric Company, Schenectady, N. Y., s plans under way for the erection of a manufacturing ant on Elmwood avenue, Philadelphia. The building d necessary machinery will cost approximately $500,-0. Switchboards and similar apparatus will be manuctured at this plant.

H. A. Kuehle, who has been engaged in the sale of wer apparatus for the Western Electric Company, has en placed in charge of railroad sales in the Cleveland fice. Mr. Kuehle graduated from the Case School of pplied Science in 1904 and has been with the Western lectric Company since 1914.

Harry L. Oviatt has been appointed traveling repsentative of the Armstrong Manufacturing Co. of ridgeport, Conn., manufacturers of pipe threading tools d taps. Mr. Oviatt has been with the Bullard Machine ool Co. for the past thirteen years and for the past ree years has been connected with the advertising partment.

The Spanish Northern is asking for bids, through e Spanigsh government, for materials to electrify a porn of its line, according to cable advices from Comercial Attache Cunningham at Madrid. Bids will be ened also on April 22 covering the construction of a eam railway from Soria to Castejon. It is also said at the government will soon be in the market for more rs and locomotives.

The Hazard Manufacturing Company, manufacturs of wire rope and electrical wires and cables, February 1 opened a new sales office and warehouse at 1701-1703 First Avenue, Birmingham, Alama, in charge of R. J. Bravand, district manager. Mr. ravand's connection with the Hazard Manufacturing ompany covers a period of twenty-two years, partly at e plant and partly in the field. Of recent years he has een service engineer, and in that capacity made an insive study of wire rope uses, particularly as applied mine hoisting and haulage. A full stock of wire rope d rubber insulated wire will be carried in the new irmingham warehouse.

The New York Central has notified its "unskilled" orkmen—freighthouse men, platform, storehouse men, eight handlers, trackmen, track walkers, car laborers, hpitmen, etc., to send representatives to a conference ith officers of the company to be held in New York City March 8, when revisions of wages will be proposed, to into effect on April 1. It is understood that about 30,000 employes of the New York Central are affected by this notice. Many of them have no organization, and, apparently, committees will have to be chosen this week. Any properly accredited representative of 100 or more men of any craft, whether connected or not connected with a brotherhood, will have a standing in the conference. The other roads in the New York Central system have as yet taken no action in this direction. The large majority of unskilled laborers are now receiving about 48.5 cents an hour, which is higher than the prevailing rate in most cities on the lines of the New York Central.

Chile to Use Water Power

Vast natural water power resources in the central provinces of Chile are to be put to use to generate electricity for Santiago, Valparaiso and neighboring cities and towns. A company, capitalized at $3,250,000, has been formed for the purpose, and work already has been started on a hydro-electric plant on the Colorado River, near Santiago, where it is expected 18,000 horsepower can be developed. The project is backed largely by Chilean capital.

Basis for the promotion of the company was the need of more power by both the Valparaiso and Santiago street railways, and by mining and industrial enterprises. Until recently no water power concessions in Chile were granted by the President of the republic for more than thirty-five years, but the latest concessions are said to be perpetual.

Western Electric Employees Start Building and Loan Association

Employees of the Western Electric Company at its big plant near Chicago have evolved their own scheme of solving the rent question. The Hawthorne Club, the plant employees' organization, which has over 25,000 of the factory personnel on its membership lists, has developed two plans. One offers a means of lowering the costs per person desiring to build; the other is a financing system on the building and loan idea.

The State of Illinois has just granted a charter to the Hawthorne Club Savings, Building and Loan Association for a period of ninety-nine years.

The new association is issuing three classes of stock to its members. Its Class A stock, which has a maturity value of $100 per share, is paid for at the rate of 25 cents a week per share. At the average profit of a building loan organization the A securities will be paid for in 328 weeks or a little more than six years. The subscribers who are anxious to build can obtain a loan representing the entire maturity value of the stock to which they have subscribed, immediately after their application for the stock is accepted. It has been figured that they will pay only a trifle

over 3 per cent a year on their debt instead of the legal 6 per cent. They will save all the mortgage renewal fees, and many of the legal fees that weigh down the average homebuilder. They are saved from the danger of falling into the hands of financial sharpers.

The Class B stock is similar to Class A except that it is paid at the rate of 12½ cents a week. It matures in about eleven and a half years.

The Class C stock is issued on payment of $75 per share. It participates in the association's profits. As soon as the profits reach $25 a share the stock can be cashed at its maturity value of $100.

The Hawthorne association operates under a serial plan. Members are admitted only on the first Thursday in March, June, September or December.

A board of employee directors passes on all loans before they are granted. There are nine members. The average term of service with the Western Electric Company of the men on this board exceeds 18½ years. Some of them are experts in appraising Chicago property.

Although just getting under way the Hawthorne Association has about all the business it can handle comfortably, 534 subscribers having taken a total of 6,812 shares in the two series which have been issued. The board of directors is now acting upon applications for loans totaling approximately $50,000.

Niagara Power Plant Granted 50-Year Lease

The Niagara Falls Power Company was granted a fifty-year license recently by the Federal Power Commission to use 19,500 cubic feet of water a second from the Niagara River above Niagara Falls. The limit set by the Canadian-American treaty is 20,000 feet.

The company at present is using practically 20,000 feet under a consolidation of power companies, effected as a war measure.

Under the permit the company must hasten extensive improvements and enlargements of its plants, and must extend a new transmission line across Grand Island to Buffalo and another to supply power to the Niagara, Lockport and Ontario Company, now purchasing its power from Canada under one-year contracts.

The additions required by the permit will increase the plant's output from 300,000 to 400,000 horsepower.

Electrification in South Africa

The South African Railways are advertising in the United States for bids for materials to be used in the electrification of their lines between Capetown and Simonstown and between Durban and Pietermaritzburg. The following materials will be needed for the Capetown project: Motor coaches and underframes, motor bogies, electrical equipment for coaches, substation equipment and power station transformers, boilers and boiler house equipment, turbo-alternators and condensing plant. For the work at Durban the following materials are desired: Electric passenger and freight locomotives, electric switching locomotives, substation equipment, boilers and boiler house equipment, turbo-alternators, condensing plant and transformers for substations and power stations. It is understood that the Capetown project is a multiple unit proposition and the one at Durban primarily to secure cheaper operation on heavy grades.

Specifications can be obtained from the High Commissioner for the Union of South Africa, 32 Victoria street, S. W. 1, London, England. The charge for these is £5 5s. for the first copy and £2 2s. for additional copies. Sums expended for these specification up to three will be refunded upon receipt of bona-fide bids. Bids will be received by the High Commissioner at London up to May 3. It is understood that the total cost of the work will exceed $20,000,000.

A. R. E. A. Program

The program for the twenty-second annual convention of the American Railway Engineering Association, which will be held in the Congress Hotel, Chicago, on March 15-17, is as follows:

TUESDAY, MARCH 15

President's address.
Reports of secretary and treasurer.
Reports of committees on:
- Signals and Interlocking.
- Ballast.
- Stresses in Railroad Track.
- Electricity.
- Track.
- Rail.
- Standardization.
- Uniform General Contract Forms.

WEDNESDAY, MARCH 16

- Signs, Fences and Crossings.
- Ties.
- Iron and Steel Structures.
- Water Service.
- Economics of Railway Labor.
- Economics of Railway Operation.
- Economics of Railway Location.
- Shops and Locomotive Terminals.
- Buildings.

Annual dinner at 6.30 p. m.

THURSDAY, MARCH 17

- Masonry.
- Roadway.
- Wood Preservation.
- Wooden Bridges and Trestles.
- Yards and Terminals.
- Rules and Organization.
- Records and Accounts.

Conservation of Natural Resources.
New Business.
Election and installation of officers.
Adjournment.

Speakers at the annual dinner at the Congress Hotel will include John F. Wallace, consulting engineer, New York, and David Kinley, president, University of Illinois, Urbana.

Mail Across Continent in 33 Hours

Postoffice department airplanes carried 300 lb. of mail from San Francisco to New York, about 2,700 miles, on February 22 and 23, in 33 hours 20 minutes, less than half the best time previously made, this being accomplished by keeping up the flying all night. The time actually on the wing was 25 hours 53 minutes. The record as given in press despatches is as follows:

SPECIAL AIRPLANE MAIL TRIP, FEBRUARY 22 AND 23

	Pac. time	E. time	Pilot
San Francisco, left Tuesday	4.30 a.m.	7.30 a.m.	.....
Reno	.....	.....	
Salt Lake	.....	.....	
Cheyenne	5.10 a.m.	8.10 p.m.	Knight.
North Platte	.....	.....	
Omaha	.....	.....	
Iowa City	.....	.....	
Chicago, arrived Wednesday	6.40 a.m.	9.40 a.m.	Webster.
Chicago, left	7.00 a.m.	10.00 a.m.	
Cleveland, arrived	10.52 a.m.	1.52 p.m.	
Cleveland, left	11.03 a.m.	2.03 p.m.	Allison.
Bellefonte	.....	.....	
New York	1.50 p.m.	4.50 p.m.	

The landings for fuel and refreshment at North Platte, Omaha and Iowa City, were made by the aid of flares marking the boundaries of the landing fields. Knight, the night flyer, steered his course of about 1,000 miles by compass. With the route from Omaha to Chicago, about 500 miles, he was wholly unacquainted.

These successful flyers were not the only ones who made the experiment on that day; westbound as well as eastbound trials were made; and one of the eastbound flyers, Capt. W. E. Lewis, was killed at Elko, Nevada.

Personals

E. E. Hudson, vice-president and general manager of the Waterbury Battery Company, Waterbury, Conn., has been elected president of the company to succeed Charles B. Schoenmehl, deceased, and Francis T. Reeves has been elected treasurer. Mr. Hudson for the past 22 years, with the exception of a little over a year's time, has been in the sales and managerial departments of concerns manufacturing primary batteries and has been identified with the installation of the primary battery. In July, 1898, he served as chief clerk in the primary battery sales department of the Edison Manufacturing Company, remaining in that position until June, 1902. Shortly afterward, he served as an accountant in the controller's department of the United States Steel Company. In December, 1903, he became secretary and treasurer of the Battery Supplies Company, Newark, N. J., and in 1905 was appointed sales manager of that company. When the Edison Company absorbed the Battery Supplies Company, in 1908, he was appointed assistant manager of sales in the primary battery department. He became sales manager of that department in February, 1909, and in September, 1913, was elected also vice-president. In October, 1914, in addition to these duties, he was given charge of the manufacturing, as well as the sales, and in March, 1915, was made division manager in general charge of the entire primary battery business of Thomas A. Edison, Inc. In 1914 he was chairman of the Railway Telephone & Telegraph Appliance Association, and in 1916 he was chairman of the Signal Appliance Association, previously having been a director. He also served for seven years as a director of the National Appliance Association, which is to the American Railway Engineering Association what the Signal Appliance Association is to the Railway Signal Association. On January 1, 1917, he was elected vice-president and general manager of the Waterbury Battery Company, and now becomes president of the same company.

E. E. Hudson

Hugh Pattison has resigned from the heavy traction department of the Westinghouse Electric & Manufacturing Company, where he was engaged in making special engineering studies under the direction of F. H. Shepard, to accept a position with the Illinois Central Railway in connection with the electrification of that road. During his career as an electrical engineer, Mr. Pattison has been associated with some of the largest electrification projects. He was graduated from the Johns Hopkins University, electrical engineering course, in 1892. The first work that he did upon leaving college was the wiring and installation of electrical apparatus on naval vessels at the Navy Yard in Norfolk, Va. At this place he held the position of foreman. He became assistant engineer with Sprague, Duncan & Hutchinson, consulting engineers of Baltimore, in 1893. Shortly afterward he became associated as engineering assistant with Frank J. Sprague, vice-president and technical director of the Sprague Electric Company in New York. This association continued until 1903, during which time Mr. Pattison assisted in equipping and operating multiple unit control on the Boston Elevated and Brooklyn railroads. In 1905, Mr. Pattison joined the Westinghouse, Church, Kerr Company as an engineer, and from that time until 1911, during the electrification of the Pennsylvania tunnel into New York, Mr. Pattison was assistant engineer of electric traction for George Gibbs, consulting engineer. A little later he had charge of the electrification of the West Jersey & Seashore Railroad, from Camden to Atlantic City. An experimental single phase electric railway on the Long Island Railroad was also built by him and numerous locomotive tests on the West Jersey & Seashore Railroad were carried out under his supervision. Mr. Pattison was appointed engineer in charge of the Chicago Association of Commerce Committee in the study of smoke abatement and the electrification of terminal railroads in Chicago in 1911. The experience gained in connection with this latter position will doubtless be of value to Mr. Pattison in the position which he now goes to fill.

George J. Kirkgasser, who has been in charge of sales promotion work, advertising and publicity for the Cutler-Hammer Manufacturing Company, Milwaukee, since 1914, has recently resigned and established an office in Chicago under the name of George J. Kirkgasser & Company. This organization will furnish a service to industrial and engineering concerns in advertising, merchandising and the development of cooperation between works departments, selling departments, outside offices and distributers. Mr. Kirkgasser was graduated in electrical engineering from Syracuse University in 1907 and for three years following this was engaged in engineering work. In 1910 he became identified with the Cutler-Hammer Manufacturing Company as assistant advertising manager and technical writer, a position he held until he was made advertising manager in 1914. Mr. Kirk-

gasser has contributed many engineering articles to the technical press and is the author of "Electric Light and Motor Wiring," "Electric Control Engineering" and "Motors and Motor Control."

Obituary

Charles B. Schoenmehl, president and treasurer of the Waterbury Battery Company, Waterbury, Conn., died on February 14, at his home in Waterbury. Mr. Schoenmehl was born in New York City in November, 1858. At the age of 15 he entered the employ of the Benedict & Burnham Company and afterward went to the Waterbury Brass Company in the tube rolling department. During his employment with the latter company he first took up the study of electro-chemistry.

C. B. Schoenmehl

He commenced experimenting with electric batteries in the early eighties; his first attempt to market a battery was about 1884, while in the employ of the Waterbury Brass Company, when he made and sold to physicians in and about Waterbury batteries for use with medical coils. These batteries were made by him at night after his day's work in the brass company. In 1886, he developed a new type of open circuit cells, and about this time he began taking out patents covering batteries in general. The first type of battery marketed under a trade name was the Victor cell.

In 1896, the Excelsior cell was placed on the market, this was of the cylindrical type and was based upon patents which were kept more or less active by additional combination and improvement patents. Up to 1896, he did all the work of manufacturing and selling his battery product himself, still producing at night such batteries as were sold, and retaining his employment in the Waterbury Brass Company.

The Waterbury Battery Company was organized in 1898 with a few hundred dollars Mr. Schoenmehl had borrowed to start operations. Subsequently he secured additional finances from a friend but this was all repaid later from the profits of the company's business. The company started operation with one employee, and its manufacturing plant consisted of a small building 20 ft. by 30 ft.

The first product of the company was the Excelsior battery. In 1904, a new compressed cylinder type of copper oxide cell was presented to the trade under the trade name of Schoenmehl's primary battery. This type, in modified form, is still being sold in large quantities, and the present Unit cylinder type of cell now being featured by the company is the further development of this original cylinder type. In 1906, the company placed upon the market a plate type of battery. This type, with certain modifications, also a high internal resistance or track circuit type of primary battery produced in 1912, are still being made.

During 1912, Mr. Schoenmehl put out his multiple plate type element and the same year he acquired the business and plant of the Gordon Primary Battery Company. In the acquisition of this business, he obtained all the patents covering the Gordon battery to which he subsequently added combination and improvement patents.

Mr. Schoenmehl was a prolific inventor. Since the organization of The Waterbury Battery Company he has invented and patented in the United States and Canada a great many improvements in primary batteries as well as other devices including patents covering the electro-deposition of metals, and he originated and devised the method of electro-deposition of copper now in use in some of the great mining centers of the West. Altogether Mr. Schoenmehl has taken out upward of 60 patents in the United States.

Trade Publications

Electro-Dynamic Company, Bayonne, N. J., is distributing its bulletin No. 220, illustrating and describing its Type B Form K polyphase induction motors. The motors have rotors of the squirrel cage type and are equipped with ball bearings. They are built in sizes from 15 to 200 hp.

"Achievement" is the opinion of a folder being distributed by The J. G. White Engineering Corporation, 43 Exchange Place, New York City. It gives information about and illustrations of power developments, hydro-electric developments, transmission systems, and other important engineering projects in this and in foreign countries.

Wagner Electric Manufacturing Company, St. Louis, Mo., is distributing its Bulletin 124 which describes and illustrates instrument transformers. The bulletin contains 12 pages, and is well illustrated with various types of transformers. Both photographs and dimension drawings are included, as well as connection diagrams.

General Electric Company, Schenectady, N. Y., is distributing its Bulletin No. 49714 C describing and illustrating static condensers designed for the purpose of overcoming the detrimental effect of a low power factor This type of condenser does not require an attendant for its operation. A number of curves, charts, diagrams of connections, drawings and tables on prices, dimensions, losses and weights in the case of condensers, circuit breakers and transformers are provided. The illustrations include photographs of actual installations.

The Edison Lamp Works of the General Electric Company, Harrison, N. J., has issued 9, new and very comprehensive, bulletins on the general subject of lighting data. The following is a list of the titles and bulletin numbers: The Lighting of Armories and Gymnasiums, L. D. 115; The Edison Mazda Lamp for Stereopticon Service, L. D. 116; Calculation of the Lighting Insulation, L. D. 117; The Incandescent Lamp—Its History, L. D. 118; The Manufacture of the Edison Mazda Lamp, L. D. 119; The Lighting of Coal Mines, L. D. 120; Medical Lighting Including Hospitals and Dental Offices, L. D. 121; Commercial Photometry, L. D. 122; The Lighting of Shoe Factories, L. D. 124.

Railway Electrical Engineer

Volume 12 APRIL, 1921 Number 4

The *Railway Electrical Engineer* deals primarily with electric welding. As parts of some jobs are done with gas welding and parts with electric, and as some jobs done with gas might as well or better be done by the electric process, some gas welding subjects will be dealt with from time to time. Elsewhere in this issue appears specifications for metal electrodes and welding rods issued by the American Welding Society. These specifications include material for the welding of mild steel only, but cover both the metal electrodes for electric welding and rods for gas welding. One set of specifications is incomplete without the other, as almost all roads use both the gas and electric processes, and if the specifications are to be used it is necessary to have both to avoid a certain amount of duplication. Other specifications to be issued at some time in the near future will deal with the welding of high carbon steel and with non-ferrous metals, respectively.

Standards in Electric Welding

These specifications are published at this time, as they have not as yet received the distribution in the railroad field warranted by so good a piece of work. There is as yet very little which has been adopted as standard in the welding field. For this very reason the results obtained on certain classes of work vary from zero to 100 per cent. In some localities the welding of certain parts is condemned as impracticable, while the same work in other localities is everyday practice. Welding is extremely valuable in the railroad field and anything which will tend toward standardization, or the wider application of the work, will increase this value.

The work of electrification is about to begin on two sections of the South African Railway. These sections are the Cape Town-Simonstown Suburban line, 22 miles long, and the Durban-Pietermaritzburg section of the Natal main line, 70 miles long. The electrification of the Simonstown line was decided upon because of the heavy passenger traffic entirely, but the Durban-Pietermaritzburg section presented many difficulties because of steep grades, heavy freight traffic and tunnels. In this respect the problem is similar to that of the Chicago, Milwaukee & St. Paul, and when this section is completed it is expected that more of the main line will be electrified.

Electrification, Foreign and Domestic

Another progress report was recently issued by the French Commission in the United States which tells of electrification progress in France. The Midi Company already has 90 miles of electrified line, and the work of electrifying an additional 1,800 miles is in actual progress. In addition to this, the Orleans and the Paris, Lyons & Mediterranean will each electrify 1,800 miles of their lines. It is estimated that the saving in coal resulting from this electrification will more than pay the interest on the necessary loans. The reconstruction of the destroyed lines alone presented to French railways a problem of staggering proportions. The way they have solved it and are now undertaking to carry out other plans comparable in size and importance to the reconstruction of the destroyed lines, merits the admiration of everyone. Other foreign countries are finding it absolutely necessary to adopt electrification.

The time is gradually approaching in this country when certain sections of railroads must be electrified. It is to be hoped that the roads here will not be forced to defer electrification because of lack of capital for major improvements, but will soon be in a position to anticipate future needs. As compared with foreign countries, it will probably be advisable to electrify comparatively few sections immediately and the best of engineering skill and judgment will be required to select the sections in which it will be most advantageous. An article on the fundamentals of rational electrification will be published in the next issue of the *Railway Electrical Engineer,* which will undoubtedly be of interest and assistance to all those interested in the problem.

In the last issue of the *Railway Electrical Engineer* we called attention to the beginning of a new department known as the "Interchange," a portion of which, designated as the "Question Corner," was inaugurated solely for the purpose of answering, so far as possible, those questions which most perplex the practical man in the field. For a beginning an abstract problem was given and we have been more than pleased with the answers received. It is not our intention to confine the subjects of the "Question Corner" to abstract problems, however, as may be seen from the questions which appear this month for answer in May. In fact, it is hoped that the majority of the questions will be of a sound, practical nature which will be most helpful to the electrical men in general. We want our readers to derive the greatest benefit from this department. Do not hesitate to send to the editor any questions which may be puzzling you. All questions will be treated confidentially and answered first by mail. In order that all may profit, the questions and answers will be afterwards published but without the writer's name.

The Question Corner

Is there not something you would like to know?

Why Set the Clock Ahead?

The Daylight Saving Season is again at hand and with it comes the same jumble of time that was such a nuisance last year. As has been the case from the beginning the advocates of the plan are found almost exclusively in the city while the rural population opposes the practice as strongly as ever. As a state law New York has repealed the bill with the proviso that any city or town may adopt a local daylight saving measure of its own if it so desires. The result will be a repetition of the confusion between city and railroad time that was such an annoyance last summer.

There are as many excellent arguments in favor of the daylight saving practice as there are against it, but it is questionable if the benefits derived can offset the nuisance incurred by juggling local clocks twice a year. Daylight saving has never meant but one thing and that does not necessarily demand that the clocks of a community be tampered with. If any particular community cannot be induced to go to work an hour earlier without fooling itself by setting the town clock ahead then such community ought to forfeit any benefits that accrue from the daylight saving plan. Why cannot any office or shop post a notice worded perhaps as follows:

Beginning on April 25 and ending on September 24 the working hours of this office will be from 8 A. M. to 4. P. M.

The effect to the employee is precisely the same as the result would be by setting the clock an hour ahead and all of the confusion of change in time is avoided. When daylight saving was a national measure confusion could not exist, but as a local matter in constant conflict with train schedules we say "let the clocks alone."

The Semi-Annual Convention

It has been decided not to hold a semi-annual meeting of the association of Railway Electric Engineers this year. This is not at all surprising in view of the fact that the Railway Supply Manufacturers' Association will not hold their exhibits. The semi-annual meeting in the past has consisted of the presentation of progress reports and was overshadowed by the importance and value of the exhibits.

There is also another factor which cannot help but have its influence. In the past both Section 3, Mechanical of the American Railway Association and the A. R. E. E., have discussed electrical subjects at the June conventions. This has resulted in a certain amount of duplication and it has been notable that the discussions of papers presented before the A. R. A. have been extremely brief, as if those interested in things electrical did not want to take the time of the others present. On the other hand, the members of the A. R. E. E. have taken most of the time with the discussion of detail as if afraid to take hold of many of the larger issues. Arrangements have been made for absorbing the A. R. E. E. in the A. R. A., but as yet no action has been taken. This movement will probably benefit both associations, but the delay and uncertainty does not make for action. When the A. R. E. E. has been taken in formally and arrangements for the handling of subjects have been threshed out, the electrical men should be in a better position than ever before to work out their own problems, but until then they will be working at a disadvantage.

New Books

Electrical Pocket Book, 1921 Edition. Published by Emmott & Co., Ltd., 65 King Street, Manchester, England. 377 pages, illustrated, 4 in. by 6¼ in., bound in cloth.

The Electrical Pocket Book, being an English publication, confines most of its material to the British practice of electrical engineering. In most respects it corresponds closely to similar electrical hand books published in the United States, the noticeable difference being in the references made to British standards and authorities. The number of subjects discussed is large but the treatment of each is necessarily brief. Numerous line drawings are included to illustrate and supplement the text and the usual tables for engineering calculations are included. A list of principal abbreviations, from the British viewpoint, are given and the final fifty-pages of the book are left blank to be used as a memorandum and diary for 1921.

Proceedings, Association of Railway Electrical Engineers, 1920, 6 in. by 9 in., 186 pages of text, illustrated. Published by the Association of Railway Electrical Engineers, Chicago, Ill.

The book contains the proceedings of the semi-annual convention of the A. R. E. E. held at Hotel Dennis, Atlantic City, N. J., June 14, 1920, and the proceedings of the twelfth annual convention held at the Auditorium Hotel, Chicago, Ill., October 18 to 22, 1920. The subjects considered by the association are the electrical problems of steam railroads. The particular subjects included in the 1920 proceedings are as follows: Report of Committee on Illumination; Report of Committee on Electric Welding; Report of Committee on Locomotive Headlights; Report of Commitee on Stationary Power Plants; Report of Committee on Heavy Electric Traction; Report on Train Lighting Equipment and Practice; Report on Electric Repair Shop Facilities and Equipment; and the Report of the Committee on Power Trucks and Tractors.

Connecting Induction Motors. By A. M. Dudley. Published by McGraw-Hill Book Company, Inc., 370 Seventh avenue, New York. 252 pages, 6 by 9 in. Bound in cloth.

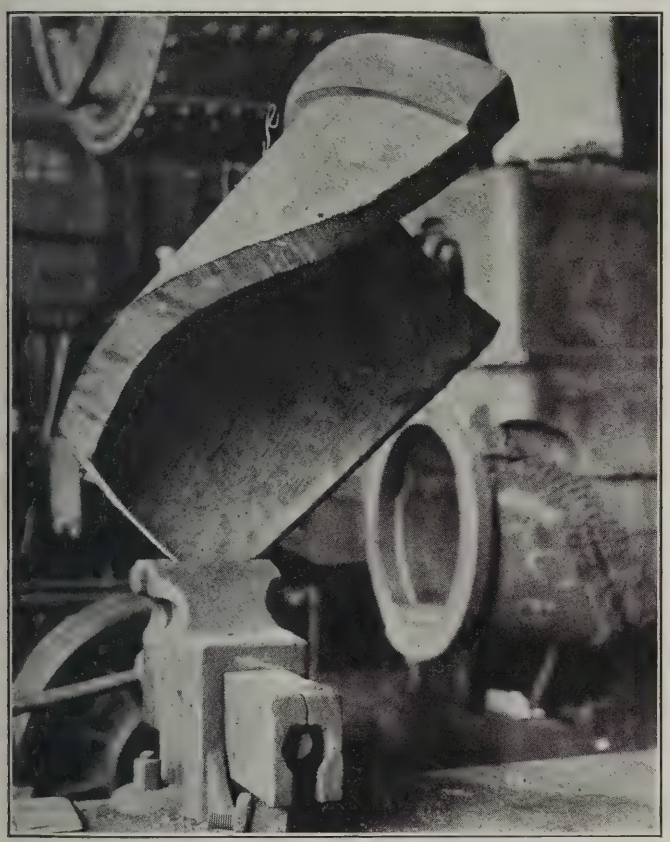
The book is a discussion of the practical application of a designing engineer's experience to the problems of operating engineers, armature winders and repair men. The treatment covers the practical questions arising in winding and connecting alternating current motors. It includes 92 standard group and wave diagrams. The various sections of the book are as follows: What the Winding on an Induction Motor Accomplishes; The Rotating Magnetic Field; Types of Windings; Chorded Windings, or the Effect of Coil Throw on the Magnetic Field; Effect of Voltage on Windings and Possibility of Connecting a Winding for More Than One Voltage; How the Number of Phases Affects the Windings and the Result of Changing Voltage and Phase at the Same Time; How the Frequency Affects the Windings; The Number of Poles and the R. P. M. and the Possibility of Varying Them with the Same Winding; Less Common Connections Used for Unsymmetrical Conditions or in an Emergency; Reconnecting an Old Winding for New Conditions; Locating Faults in Induction Motor Windings; How to Figure a New Winding for an Old Core; Standard Group Diagrams from Two to Fourteen Poles, and Wave Diagrams.

Practical Welders Discuss Their Work

American Welding Society Men Explain in Detail How They Make Various Types of Welds

ON March 15, the Metropolitan section of the American Welding Society held its regular monthly meeting at the Engineering Societies building in New York City. The program for the evening was something of a departure from the usual type inasmuch as it did not consist of a single prepared paper by a single speaker but was made up chiefly of brief talks by practical welders who explained in detail just how they accomplished the various results in their several shops.

The first speakers of the evening were two men employed by the Electric Arc Cutting & Welding Co. of



Wooden Pattern Exactly the Same Sizs as Broken Out Portion of Cylinder. Repairs Were Made by Using the Casting Made From This Pattern

Newark, N. J. They were G. Maubourene and H. Clark. These men described the method which they used in welding the spoke of a cast iron fly wheel which had broken in service. The fly wheel in question formed a part of the operating equipment of a plant which was run seven days a week and for this reason it was desired to expedite the repairs as rapidly as possible. These two men worked on opposite sides of the broken spoke using two arcs in series.

The second speaker was Paul Wittig, employed at the Kingsland Shops of the Delaware, Lackawanna & Western. Mr. Wittig explained the manner in which a broken engine cylinder had been recently repaired. Lantern slides were shown to illustrate the various steps in the repair of this cylinder and a number of features developed which differed somewhat from the practices used on the other roads. The parts broken from the cylinder had been so completely destroyed that it was necessary to recast an entirely new portion and a wooden pattern was made which conformed exactly to the size of the broken off part. The new cast section made from this pattern was then studded with a large number of small steel studs as was also the unbroken portion of the cylinder. The question of placing studs in cast iron for the purpose of welding is not new but the type of studs used in the Kingsland shops of the Lackawanna differs in some respects from those used on other roads. The stud itself is somewhat smaller and their practice is, at that point, to use a great many of these studs. A portion of the stud is threaded and screwed into the tap hole in the cast iron in the usual manner. About a half inch above the end of the threads on the stud, a deep recess is cut so that the stud is materially weakened at this point. In applying the stud, a wrench is used on the end and as soon as the thread has been turned as far as possible into the tapped hole, further effort applied to the wrench causes the stud to break off at this weakened point, which it is designed to do. This breaking off feature gives a very clean bright surface and one which may be readily welded to without the additional trouble of carefully cleaning.

John Marr, also an electric welder at the Kingsland shops, gave a brief description of the method he used in welding fire boxes.

The subject of oxy-acetylene welding was taken up and discussed at considerable length by Fred E. Rogers of the Davis-Bournonville Co. of Jersey City, N. J. Mr. Rogers described the application of gas welding to the construction of refrigerating apparatus and illustrated his talk with a large number of lantern slides.

Charles L. Messer, formerly employed at the West Albany shops of the New York Central, described briefly the method used by that company in welding broken cylinders and other standard cast iron parts. The stud method used by the New York Central varies somewhat from that used by the Lackawanna in that the studs used on the former road are considerably larger and fewer in number than those used on the latter. Moreover, instead of breaking off the studs in the manner used on the Lackawanna, they are thoroughly cleaned before welding.

The foregoing speakers gave extemporaneous talks, none of them having prepared any papers on the particular subjects.

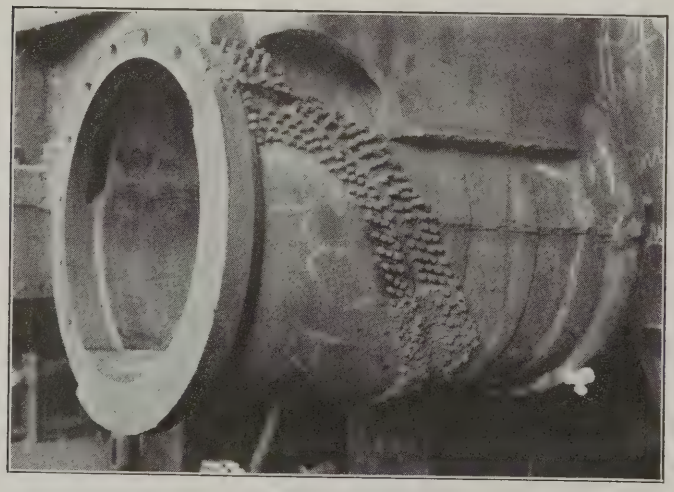
Edward Eldridge, foreman of electric welders at the Elizabethport shops of the Central Railroad of New Jersey, also spoke extemporaneously with reference to the welding work that is being performed at the shops. Mr. Eldridge, however, had placed most of his ideas in a paper which he had brought along, but which his natural ability as a speaker and his enthusiasm for his work did not permit him to read. The following paragraphs

are abstracted from the paper which Mr. Eldridge had prepared:

In discussing the subject of electric and acetylene welding at the Elizabethport shops of the Central Railroad of New Jersey, I may say that we have had wonderful success in both boiler and locomotive work. In the erecting shop we weld frames, cylinders and castings of all kinds, both with the electric arc and acetylene. We also weld superheater units. In the machine shop department we are welding cross heads, valves, driving wheels and building up worn parts that are too numerous to mention. The boiler department also comes in for its share and here we are welding whole fire boxes, ½ fireboxes, ½ throat sheets, backheads, door-rings, patches, large cracks, flues and patches on tanks.

Frame Welding

When welding broken engine frames, the frame is trammed and leveled after which it is V'd out about 45 degrees on both sides with the acetylene cutter. It is then chipped to remove all scale and burned material. The next step is to expand the frame about ⅛ of an inch in order to take care of contraction. To get this expansion we use a charcoal fire on the rail that is not broken, and as this expands, it will open the one in which the break is located. Two welders are then put on to weld, one on either side. When they get one layer welded on, they take an air hammer and bob it to get the scale and dirt off before starting another layer and continue in this way until the frame is welded flush. The welded joint in the frame is then re-enforced by use of ⅝ inch or ¾ inch round mild steel bars which are put across the weld and extend two inches on either side of it. These bars are spaced from 1 inch to 1¼ inches



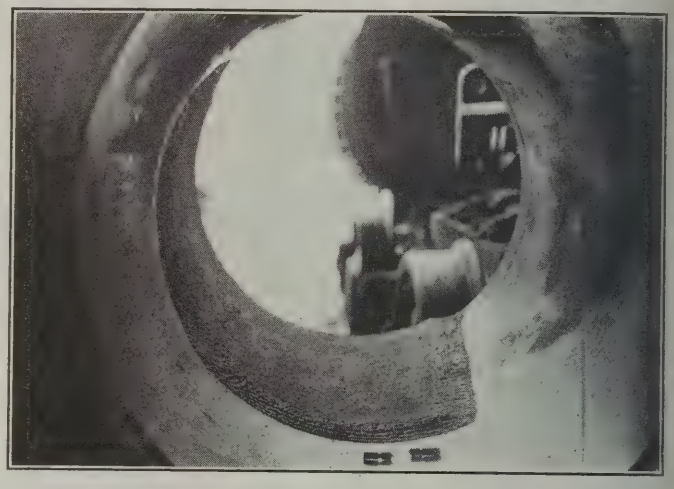
Partly Welded Cylinder Showing the Large Number of Studs Used

apart and are welded in solid where possible. Bars placed in this manner greatly increase the tensile strength of the frame at the welded joint. In welding single rail frames, the rail is expanded on the opposite end to get the expansion where the break is located. Afterward the weld is made in the same manner as in the case of the two rail frames.

Cylinder Welding

In welding engine cylinders that are cracked or broken we are doing it with both the electric arc and acetylene. When welding with acetylene, the crack or broken cylinder is V'd out to a 45-degree angle and the opening left from ⅛ inch to 3/16 inch on bottom of the crack. A frame is then built around the cylinder which is heated to a cherry red heat with a charcoal fire before starting to weld. In using an alloy cast iron rod for filler, care must be taken not to chill the iron or it will be hard. After the weld has been completed and has cooled, the furnace is taken away and the cylinders bored or trued up.

In welding engine cylinders with electric metallic arc, all cracks or broken parts are V'd out or beveled to a 45-degree angle and studs applied. Various size of studs



Interior of Cylinder After the Weld Was Completed, But Before Being Bored Out. Two of the Studs Are Shown in the Lower Part of the Photograph

are used according to the thickness of the casting. Where the casting is one inch or over we use a ¾ inch or a ⅞ inch stud. These are placed about two inches apart, using one row in the crack and two rows outside, one row being on either side of the crack. Wherever a new piece is set in to replace a piece broken out, we use forged steel, with studding applied only to the cast iron. In making the weld, a light layer is placed around each stud first. Then the layer is put on where the weld is going to be applied, after which you have steel to steel to weld. After the weld is finished, white lead is put on the inside of the cylinder to do away with leaks or pin holes which form next to the cast iron. When a joint comes in the weld, we braze "Tobin" bronze so as to leave a soft joint to machine. This bronze is brazed on with acetylene. If no acetylene is used, a small piece of copper is dovetailed at the joint.

Steel Casting and Other Pieces

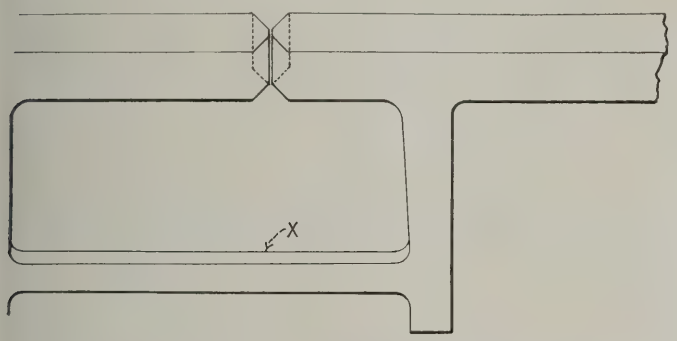
In welding broken or cracked iron, steel or cast steel castings, the casting must be V'd to about a 45 degree angle, and the crack extended through to a feather edge so that the weld will get all the way through. Care must be taken to get all grease and dirt off as this will get into the weld and weaken it. If a casting is warped out of shape, it will not spring if it is welded from both sides, a little welding being done on each side alternately until the weld is completed.

Bars of steel for re-enforcing are always used as the grain runs across the weld in all directions. In welding superheater units we found the acetylene weld was better than the electric. Where the unit is cracked on the re-

turn end, the proper way is to cut off the end about one inch in order to get into good material. A cap made of ¼ inch material is then welded on. By using a cap the weld will be on the side of the unit instead of on the end and the greatest heat will strike the cap, which is the thinnest part, and will stand this heat as the steam passing through will keep it cooler.

Machine Department

In repairing crossheads where the flanges are worn down we are welding on a ⅝ inch strip. The strip is beveled on both sides of one edge on the planer, after



Engine Frame V'd Out for Welding. By Applying Heat at the Point "X" On the Lower Member the Ends of the Frame at the Break in the Upper Member are Caused to Separate Slightly On Account of Expansion

which it is taken and welded on both sides, bringing it back to its original size. The guides which are worn on the side are built up to the original size. By applying strips 1 inch to 1¼ inches wide, beveled from both edges and welded to the sides of the guide, the guides are brought up above standard size, after which they are planed down to the proper dimensions. In building up worn castings which are to be machined down great care must be taken not to overlap the layers as this is the cause of black or hard spots in welding.

Firebox Welding

In welding complete fireboxes, we use a butt weld. The sheets are beveled on the inside and set in space on the mud-ring then tacked in the water space. All fireboxes are welded on the floor. Starting in the center of the flue sheet at the bottom, the weld is made up to the ear or lap. The firebox is then turned over and the welding continues from the center of the crown sheet to the mud-ring, giving ⅛ inch re-enforcing. After completing the weld on this side, the box is again turned and with a round nose chisel, a groove about 3/16 inch deep is cut in the seam in order to get all the scale and dirt off. This groove is then re-enforced with ⅛ inch or 1 inch layer of welding metal. On the flue sheet we put ½ inch by 3 inches round mild steel bars and weld around them. On the throat sheet five bars are used in the same way. The reason for putting on these bars is to stiffen the flue sheet when the flues are rolled. In welding half throat sheets and backheads, the sheets are beveled the same as the firebox side and welded before rivets are put into place, thus giving about 3/16 inch by ⅛ inch re-enforcing.

In welding mud-ring corners we put a fillet weld on the inside through plug holes and re-enforce ½ by 1¼ inch by 12 inches on the outside.

In welding half fireboxes we use a staggered seam starting the cut back from the throat sheet two staybolts, then up one staybolt. The seam then goes back two staybolts, down one, back two and so on the length of the firebox. By staggering seams expansion and contraction is scattered in all directions.

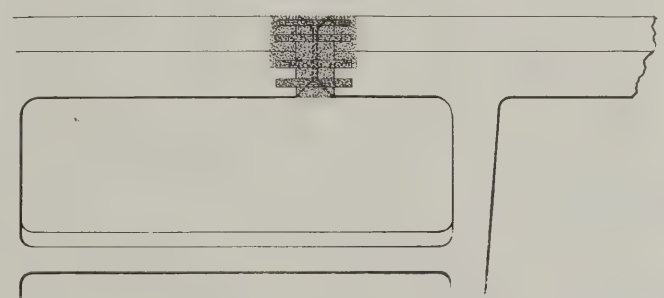
In welding patches in fireboxes we use an oval patch so there will be no sharp corners. The patch has a 3/16 inch radius so that there will not be any strain after the weld has been made. In applying the patch after the top and sides have been tacked on the weld is begun at one end of the patch and continued across the top. The ends of the patch are welded from the top down, first welding about three inches on one end and then the same amount on the other until the ends are completely welded. The patch welding is then completed by beginning at one end at the bottom and continuing to the other end, and re-enforcing about 3/16 inch. By welding this way the heat from the welding travels up into the patch and the contraction will straighten out the patch.

In welding cracks in fireboxes where they are over four inches long, the crack is V'd out to a feather edge. The welding is begun three inches from the top and the weld continues to the top. Welding is then begun about three inches further down and continues upward as before and so on until the crack is filled up. The next step is to take a welding hammer and bob up the welding material that has been applied and put on 3/16 inch re-enforcing. Cracks welded in this manner we have had hold for two or three years.

In welding door-holes we weld some with the lap and some with butt weld. In welding a lap weld care must be taken to keep the sheets layed up tight at all times and a fillet weld is applied on the edge. Care must also be exercised to see that the weld is as thick as the sheet in all places.

Flue Welding

In welding flues in the firebox end, we put the flues in the same as before welding was practiced. The boiler is then filled with warm water so that it will not sweat, and with a roughing tool all dirt and scale was cleaned from the sheet. With an acetylene torch or blow pipe all grease and oil are burned from the flue and sheet.



Engine Frame Welded Showing the Reenforcing Bars Overlapping the Weld

The work is begun at the top of the flue sheet and progresses across so that the smoke will get on the flues that are already welded and not on the ones to be welded. Always start to weld a flue at the bottom, welding up each side to the top. Care must be taken that there is no copper sticking out of the sheet as this will cause blow holes in the weld. In welding upright boilers roll and expand the flue and do not bead or use any copper

ferrules. Leave the flue about 3/16 inch from the sheet and weld the bead on.

* * * * * *

Mr. Eldrige's remarks concluded the program for the evening with the discussion of a number of questions which were asked of him and also of the several other speakers. The response of a part of the welding operators to tell of their personal experiences in making the various types of welds was most gratifying. About forty members of the New York section of the society were present and it was the general consensus of opinion that the meeting was one of the most successful that the society has ever held.

Results of Steam Railroad Electrification*

By C. C. Whittaker
Railway Engineering Department,
Westinghouse Electric & Manufacturing Co.

STEAM RAILROADS are studying the problems of electrification. Now and then some road, pressed a little harder than the others for increased road, tunnel or terminal capacity, or for lower operation costs, arrives at the solution which is the answer to its own particular requirements. That these solutions have been justified is evidenced by many statistical testimonials from these electrified roads.

Studies on the substitution of the electric locomotive for steam motive power on various railroads have indicated that the resulting operating economies are sufficient, not only to carry the charges on the capital investment, but in addition that the flexibility of this type of power permits a greater volume of traffic to be handled over the existing trackage, and thereby obviates additional capital expenditures for increased trackage required with steam operation.

Very often, where certain sections of a railroad have about reached their limit of tonnage with steam operation, it has been found that electrification would enable them to care for a 75 per cent increase in tonnage over the same trackage, and that the capital expenditure for electrification would be less than for the additional trackage and facilities to handle this same increase in business with steam motive power.

Capital expenditure for electrification of terminals has been justified solely by the fact that electric operation afforded the only means of enlarging the traffic facilities. One dead-end terminal in the center of one of our large cities handled a large number of suburban trains. The operation of steam motive power necessitated considerable switching movement in order to remove each arriving train and make it up for departure. Business had increased to that point where it was impossible to take care of the increasing traffic by the introduction of more trains. The physical location was such that it was impossible to increase the trackage facilities at any price. Electrification with the introduction of multiple unit car trains practically eliminated switching and making up of trains, and automatically increased the capacity of this terminal by at least 50 per cent. The cost of electrification was $3,000,000, and the increased earnings easily cared for the charges.

Another of the principal electrifications on a heavy tonnage coal-carrying road was undertaken primarily to increase the facilities of their present trackage. This section amounting to about 30 route miles of grade and 100 miles of trackage was the limiting factor in their operation, as it represented the congested section of the system. The study of electric operation indicated that the tonnage capacity of this trackage could be doubled with electric motive power, and that the saving on the difference in investment for electrification, and that necessary for addition steam equipment, was a very attractive figure. As a matter of fact, the traffic on this road after electrification did double, and the figures given in the report were justified. These figures are as follows:

	Electric Operation	Steam Operation
Gross investment	$2,939,000	$1,090,000
Net investment	1,849,000	.....
Operating expense	500,760	925,165
Saving in operation	$424,385	
Return on gross investment	14.45 per cent	
Return on net investment	23.2 per cent	

In this tabulation the savings were largely effected by reduced maintenance and overtime crew expense. The cost of generated power was practically the same as for the steam locomotive, due to the fact that the location was in the coal mine district, and coal was cheap.

Studies in other localities where coal is scarce and expensive, and where power is developed by hydraulic plants, show economy in operation due largely to the saving made in the cost of power. This is indicated by the results of a study of a single-track western railroad of this type, where congestion was not involved, and the general method of operation with electric power is quite similar to that of steam. The section represented 133 route miles of single track, and the following tabulation is made on the basis of providing for a 40 per cent increase in business.

	Electric Operation	Steam Operation
Gross investment	$12,561,000	$3,599,260
Net investment	8,961,740	.....
Operating expense	3,826,381	5,530,217
Saving in operation	$1,703,836	
Return on gross investment	13.6 per cent	
Return on net investment	19 per cent	

In considering steam railroad electrification, we must not look for any sudden conversion from steam propulsion to electric. From the date of the first steam engine to the present time, there appears a long succession of improvements and perfection of detail so that at no time, or certainly not at the present day, is one justified in saying that there is nothing more to expect from this system of railroading.

The development of the steam locomotive has been typical of the development of other mechanical necessities, the first efforts demonstrating little more than principles involved. From the first wood burners of a few thousand pounds weight up to the up-to-date Mallet, fitted with mechanical stokers, superheaters and all auxiliaries, and weighing several hundred tons, we get some idea of the progress made.

Coincident with locomotive development, other developments essential to the use of improved locomotives, either steam or electric, such as roadbed, rolling stock, signal service, etc., have kept pace with each other.

At the present time, when more and more is required of the railroads in the way of increasing their carrying capacity and expediting their movements, in order to meet the future demands on most railroads, there is but one economical answer, and that is to electrify.

*Abstract of an address delivered before the Providence Engineering Society, March 15, 1921.

Principles of Car Lighting By Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

IX. — More About Ampere-Hour Meter

THE use of the ampere-hour meter is so extensive that a discussion of the theory involved in its operation is believed to be a valuable supplement to the article last month which described its construction. We have therefore devoted the following installment to further explanation of this device.

Theory of the Ampere-Hour Meter

Simple Shunt Type.—Fig. 1 is a circuit diagram of a simple shunt Sangamo ampere-hour meter with the principal meter parts marked as follows:

P indicates armature element.
M indicates permanent horse shoe magnet.
MP indicates magnet poles.
S indicates shunt.
T indicates gear train.
D indicates damping disc.

The theory of the operation of the armature element is

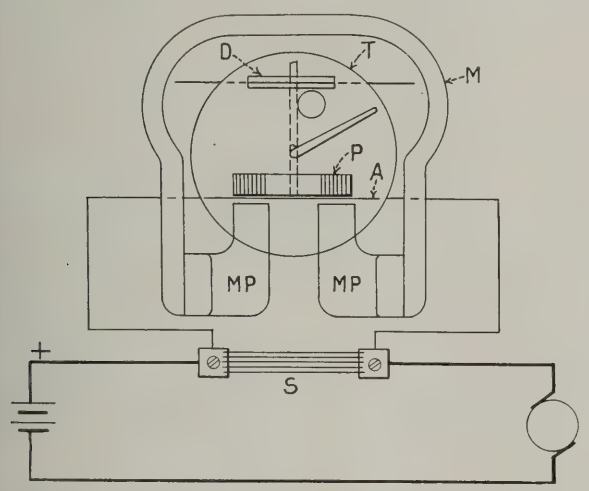


Fig. 1—Circuit Diagram of Simple Shunt Sangamo Ampere-Hour Meter

similar to that of a wire carrying current, and placed in a magnetic field, the wire tends to move out of that field in a direction perpendicular to the lines of force and perpendicular to its own axis. This is due to the reaction between magnetic lines of the field and the magnetic lines emanating from the wire carrying the current and is the same principle which makes a motor armature revolve. The force with which this wire will move out of the magnetic field depends upon the strength of the field and upon the amount of current flowing through the wire. If the field is constant and current through the wire be doubled, it will move with twice the force, etc.

The permanent horse shoe magnet in the Sangamo ampere-hour meter has two poles, a north pole and a south pole. These poles are placed one on each side of the axis of the armature, so that the current passing across the copper disc armature encounters two magnetic fields, the magnetism of one field being directly opposite in direction to that of the other. The current going through the armature reacts with a magnetic field of south polarity on one side of the axis and with the magnetic field of north polarity on the other side of the axis of the armature. The effect of these two forces acting in opposite directions at opposite sides of the armature, causes the latter to rotate. The strength of the permanent horse shoe magnet is constant, therefore the speed at which the armature rotates depends upon the strength of the current through the armature.

The direction of armature rotation is governed by the same rule that applies to a direct current shunt wound motor as follows:

1. If the polarity of the field is changed, the armature will rotate in the opposite direction.

2. If the polarity of the armature is changed, the armature will rotate in the opposite direction.

3. If the polarity of both the armature and field is changed, the armature will rotate in the same direction.

In the Sangamo ampere-hour meter the polarity of the field (which is the permanent horse shoe magnet) never changes, therefore the direction of armature rotation depends upon the direction of the current through the armature. The charging current to the battery passes through the meter shunt in one direction and the battery discharging current passes through the shunt in the opposite direction. The armature circuit is connected in parallel with the shunt circuit, therefore the direction of current through the armature will be the same as that of the shunt and the direction of armature rotation will be governed accordingly.

The damping disc rotates in the field of another permanent magnet and operates as a generator. The torque required to turn this aluminum disc is directly proportional to the speed and as the armature and damping disc are fixed to the same shaft the speed of the disc is proportional to the torque, which is in turn proportional to the current through the armature. The current can therefore be measured by counting the revolutions of the damping disc, each revolution being equivalent to a definite quantity of current. In other words, the damping disc controls the meter so that it will run at a speed directly proportional to the amount of current flowing through the armature.

The variable resistor element is connected electrically in parallel with the shunt and the armature circuits. Therefore the strength of the current through the armature will depend upon the resistance of the shunt and the variable resistor circuits. The resistance of the shunt is

constant, but the resistance of the resistor circuit varies. This variation is effected as follows: The permanent horse shoe magnet that furnishes the field for the armature element also furnishes a magnetic field for the resistor element. The reaction of the current flowing through the pivoted copper bar with the field of the horse shoe magnet causes the resistor bar to rotate. This rotating effect involves the same theory as that of the armature, but in this case the rotation is limited to a slight angle by an adjustable stop in the resistor chamber. When the current through the resistor element reverses from a charge to a discharge direction or vice versa, the resistor will rotate in the reverse direction until it strikes the other stop. An adjustable dial at the bottom of the resistor element connects through the chamber to a circular plate carrying the two stop pins, which limits the movement of the resistor bar. A graduated scale is provided so that the position of these pins may be adjusted to cause the meter to operate at any percentage of battery overcharge desired between the limits of zero and thirty per cent. The resistance of the resistor element circuit is varied by moving the pivoted copper bar of the resistor element in and out of the line of the contacts through the resistor. When the bar is directly in line with the terminals of the resistor element, the current passes from one terminal of the resistor element to the other through the copper bar giving the circuit its minimum resistance. When the resistor bar moves in the opposite direction out of the line of contact, it is necessary for the current through the resistor element to pass through a short section of mercury at each end of the resistor bar. The resistance of the resistor circuit will then be at its maximum value because the resistance of mercury is approximately sixty times greater than that of copper. As above stated, the resistor circuit is in parallel with the armature circuit, therefore an increase in resistance in the resistor circuit will send more current through the armature, causing the meter to run faster. Likewise a decrease in the resistance of the resistor circuit will shunt some of the current out of the armature circuit and cause the motor to run slower. The variable resistor element is adjusted so that the meter will record true ampere-hours on discharge and run from ten to thirty per cent slow on charge.

The theory of the thermo couple involves the principle that when two unlike metals are welded together and heat applied to the joint, a potential is generated by the action of the heat on the joint. Then when the cold ends of the welded piece are connected to an electrical circuit, a current will flow just in the same manner as if the thermo couple had been a storage battery or a generator. The thermo couple for Sangamo ampere-hour meters consists of two unlike metals welded together and connected across the armature circuit in series with an adjustable resistance. The heat is applied to the joint by means of a small electric heating coil which is wound around the joint of the two metals, and connected across the battery terminals. The potential that is generated by the heating of the joint sends a small current of approximately one-half ampere through the meter and causes the meter to creep in a discharge direction. Current for operating the little heating coil is taken either from the battery terminals direct or from the outside of the main lamp switch, as desired. In the first case, the meter will creep all the time, and in the latter, will creep only when the lights are on, the current itself being recorded on the ampere-hour meter.

Testing Sangamo Ampere-Hour Meters.—Sangamo ampere-hour meters should be tested at least once a year. The instruments required for testing are a direct current ammeter and a stop watch. As previously stated, ampere-hour meters of the differential shunt or resistor type are set slow on charge and correct on discharge. Therefore, before proceeding to test the meter it should be determined whether the meter is correct in the discharge direction. In making this test, the ammeter should be connected in series with the Sangamo ampere-hour meter, as shown in Fig. 2, and the current through the meter adjusted so that it will be constant through the period of test. The speed of the meter in the direction in which it is set correct (in this case, on discharge) is ten revolutions in thirty-six seconds at full load. The majority of Sangamo ampere-hour meters for train lighting service are rated at sixty amperes, therefore the correct speed of this meter would be ten revolutions in thirty-six seconds

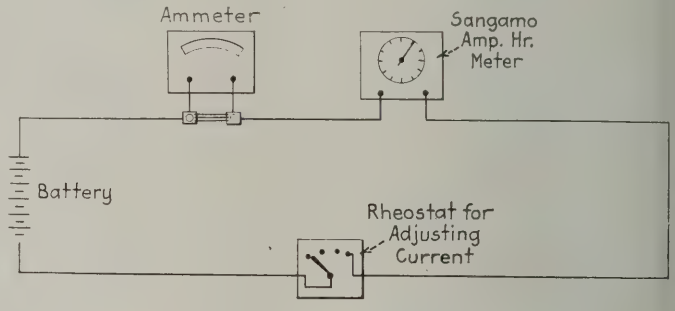


Fig. 2—Sangamo Ampere-Hour Meter Connected for Test

at sixty amperes. In checking the accuracy of a meter, the following formulæ should be used:

$$S = \frac{K \times R}{I}$$

Where K equals the constant of the meter under test, R equals the revolutions observed; I equals the load in amperes, and S equals the correct time in seconds for R revolutions. If the observed time does not correspond with the time as calculated from the above formula, the percentage accuracy can be determined by dividing the correct time by observed time, that is, if S_1 is the observed time, the percentage accuracy will be $\frac{S}{S_1}$. The constant of a ten ampere meter is 36, and is directly proportional for other sizes unless otherwise marked on meter in special cases. For example, the constant of a sixty ampere hour meter would be

$$\frac{60}{10} \times 36 \text{ or } 216$$

This constant is for the speed on discharge where the meter is set correct on discharge. If upon test the meter is found to be incorrect, it may be adjusted by varying the position of the soft iron disc located over the jaws of the permanent magnets. Raising this disc decreases and lowering it increases the speed of the meter. On light loads, that is, ten per cent of the rate of capacity of the meter, the accuracy will usually be found to be within three per cent. Unless the meter is equipped with a

thermo-couple, there is no adjustment for light load accuracy, and if the error at this load exceeds three per cent, it is advisable to clean the mercury thoroughly. Very often it will be found that there are filings or other particles of foreign matter in the magnet air gap, which drag upon the disc, resulting in the meter slowing down on light load. Therefore, before taking the meter apart, the air gap should be thoroughly clean. When the horse shoe magnet is removed from the meter, a keeper should be placed across the pole tips in order that it may retain its magnetism.

The percentage slow on charge should not be confused with the percentage overcharge, as these two quantities have entirely different values. In order to determine the

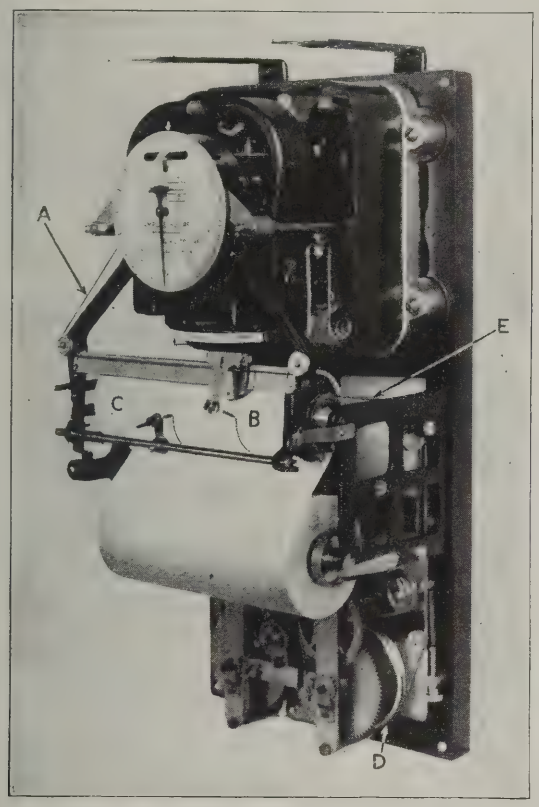


Fig. 3—Graphic Ampere-Hour Meter With Case Removed Showing Recording Pencil (B) Mounted on Rolling Carriage Moved Horizontally By Ampere-Hour Meter Gear Train

percentage slow on charge or the percentage overcharge, the following formulæ should be used:

$$\text{Percentage slow on charge } \frac{S_1 - S}{S_1}$$

$$\text{Percentage overcharge } \frac{S_1 - S}{S}$$

The following table will also be of use in determining the percentage overcharge, knowing the percentage slow on charge, or vice versa:

Percentage Slow on Charge.	Percentage Overcharge.
15	17¾
16⅔	20
20	25
25	33⅓

The following formulæ and illustration may assist in making the foregoing more clearly understood:

$$KR = IS \quad K = \frac{IS}{R} \quad R = \frac{IS}{K} \quad I = \frac{KR}{S} \quad S = \frac{KR}{I}$$

In the above formulæ K equals the constant; R, the revolutions; I is current, and S is time in seconds for R revolutions.

Suppose we take a mercury motor, variable resistor type Sangamo ampere-hour meter, with a rating of 60 amperes. Given, K (constant) 216, to find the S (time) for 10 revolutions. To calculate this time, first select the formula with the unknown quantity to the left of the equality sign, which in this case is $S = \frac{KR}{I}$. The solution would be

$$S = \frac{216 \times 10}{60} = 36 \text{ seconds}$$

Therefore, the correct adjustment of this meter will be 10 revolutions in 36 seconds with a current of 60 amperes flowing through the meter.

We have stated that a Sangamo ampere-hour meter for storage battery operation was adjusted correctly on discharge and slow on charge to compensate for battery efficiency. Suppose we assume in this case the battery efficiency to be 80 per cent. The meter speed on charge should therefore be 80 per cent of the discharge speed with the rated current of 60 amperes flowing in each case. We calculated above, the time for 10 revolutions on discharge to be 36 seconds. If the time for 10 revolutions on discharge is 36 seconds, and we desire to compensate on charge for 80 per cent battery efficiency, the correct time for 10 revolutions with 60 amperes flowing on charge would be:

$$\begin{array}{r} .80\ )\ 36.00\ (\ 45 \text{ seconds} \\ 32\,0 \\ \hline 4\,00 \\ 4\,00 \\ \hline \end{array}$$

A meter so adjusted is only recording a battery charging current of 48 amperes, although 60 amperes is actually flowing through the meter. This current of 48 amperes is obtained by using the formula $I = \frac{KR}{S}$ with S as 45 seconds instead of 36.

Starting with the battery in a fully charged condition and the hand on the Sangamo meter at the full charge point, suppose we discharge the battery through the meter at a 60 ampere rate for eight hours. The ampere-hour meter hand should now indicate that 8 x 60 or 480 ampere-hours has been taken from the battery. Now, as this meter only records a current of 48 amperes on charge when a current of 60 amperes is flowing through the meter, it would require an actual charge of 10 hours at 60 amperes, or 600 ampere-hours, to move the hand back the 480 ampere-hours to the full charge point on the meter dial. In other words, the battery receives an overcharge of 600 less 480, or 120 ampere hours. Fig-

uring this on a percentage basis, the battery received an overcharge of $\frac{120}{480}$ of 100 per cent, or 25 per cent. A Sangamo ampere-hour meter should therefore be adjusted for a 25 per cent overcharge to keep in step with a battery operating at 80 per cent efficiency.

Graphic Ampere-Hour Meter for Car Lighting Service.—The graphic ampere-hour meter, Fig. 3, is designed to give a definite indication of the treatment which any storage battery receives, both as to current rate and time of charge and discharge, and the more important information as to the actual condition of battery charge at any time. This meter is useful in checking the operation of all types of axle car lighting equipments and, since it requires no more attention than to simply install it in circuit and wind the clock once a week, it is no doubt a very useful and practical instrument in car lighting service. The operation of a graphic ampere-hour meter is as follows: The meter consists of a standard ampere-hour meter of the variable resistor type with the zero contact removed. A sheave is mounted on the main shaft of the dial hand immediately back of the dial and the small German silver chain *A*, Fig. 3, makes several turns around this sheave and is permanently connected to it.

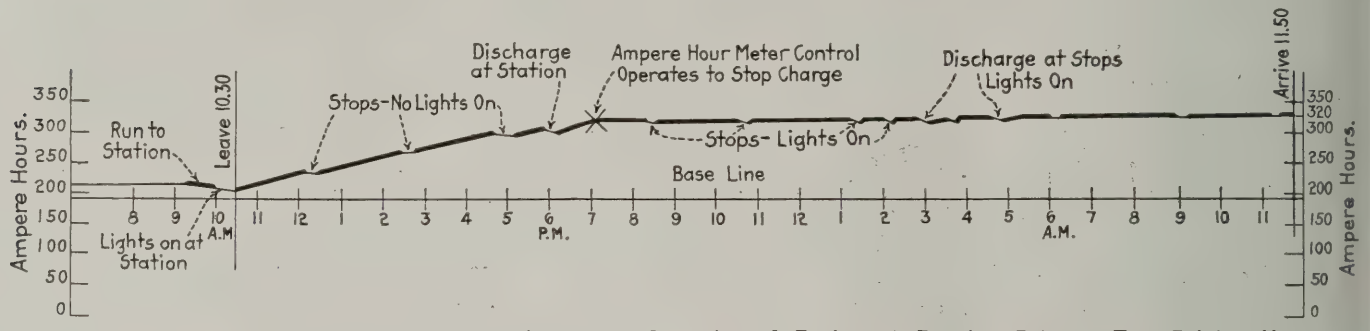


Fig. 4—Graphic Ampere-Hour Meter Chart Showing Proper Operation of Equipment Running Between Two Points. Heavy Section of Curve is Caused By Vibration Due to Moving Train. Light Sections of Line Indicate Stops

ampere-hours discharge, while a movement of the carriage in the opposite or charging direction of 1/16 in. would represent 25 per cent more than this (if the resistor element is set at this value), or 12½ ampere-hours. It might occur to some that this removable carriage for the recording pencil would add sufficient friction to cause the meter to record inaccurately; mercury meters of this type, however, have a very high torque which, acting through the reduction gear, gives a torque on the main dial shaft of 3 ft. lb. This would theoretically require a friction of 75 lb. to stop the pencil carriage. The pencil is adjustable and is usually sharpened with a flat point so as to give a fine line, and at the same time have long wearing qualities. It is supported from the movable carriage by means of a substantial spring arm, as shown, which provides proper pressure of the pencil on the paper upon which the record is made.

The stationary pencil *C* is for the purpose of giving a base line on the record sheet. This may be set at any point desired and an adjustable spring provides proper pressure of the pencil on the paper. This base line has no reference whatever to the zero capacity of the battery. It should also be considered that we are dealing with full batteries instead of empty ones.

A substantial eight-day clock movement, as shown at

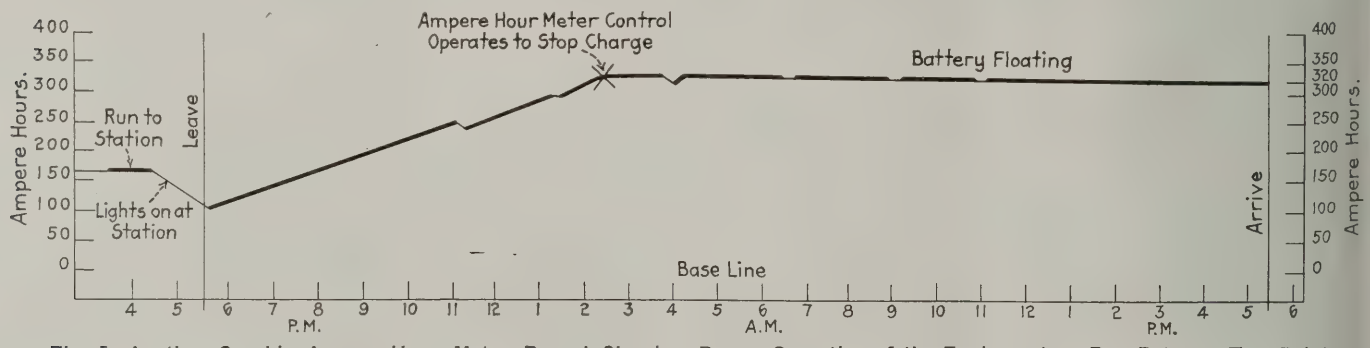


Fig. 5—Another Graphic Ampere-Hour Meter Record Showing Proper Operation of the Equipment on Run Between Two Points. Horizontal Section of the Line Indicates Battery Floating at Full Charge.

As the main dial hand of the meter slowly revolves, its motion is transmitted by means of the chain to the recording pencil *B*. This is mounted on a rolling carriage and moves with very little friction on a meter track which serves also as a guide for the carriage. The sheave mounted on the main shaft of the meter is so designed as to give a horizontal movement of the carriage of 1/16 in. for every 10 ampere-hours indicated on the meter dial. A movement of the carriage pencil *B* of 1/16 in. in a discharge direction would then represent 10 the bottom of the meter, operating through the drum *D* and cord *E*, furnishes power which moves the recording paper. The speed of motion is adjusted to approximately ¼ in. for every half hour. One foot of record tape will then represent a whole day's run, and a week's run would require only seven feet of tape. Every half hour the clock mechanism strikes, and in doing so, causes the base line pencil *C* to move transversely on the paper about ⅛ in., giving the marks of time on the base line. This automatically records the time of operation and by mark-

ing on the tape the time of starting the test, the exact time at all points on the curve is obtained.

Application of Graphic Meter.—The record of battery charge and discharge on a car running between two points is shown in Fig. 4. It will be noted that when the car is not in motion the graph of the recording pencil is light, but as soon as the car begins to move, whether the equipment is generating or not, the line becomes heavy. In this way practically all of the stops are indicated. As mentioned before, the base line has no reference whatever to the battery capacity scale, but simply gives a base line from which values of charge and discharge can be measured. For the sake of illustration, it has been assumed in the curve. Fig. 4, that the capacity of the battery when fully charged, as it was from 7 p.m. to the end of a run, is 320 ampere-hours. Since 1/16 in. equals 10 ampere-hours, the vertical scale can easily be figured. This scale has been placed at each end of the curve. The curves as recorded by the meter, however, are simply the two lines shown heavy.

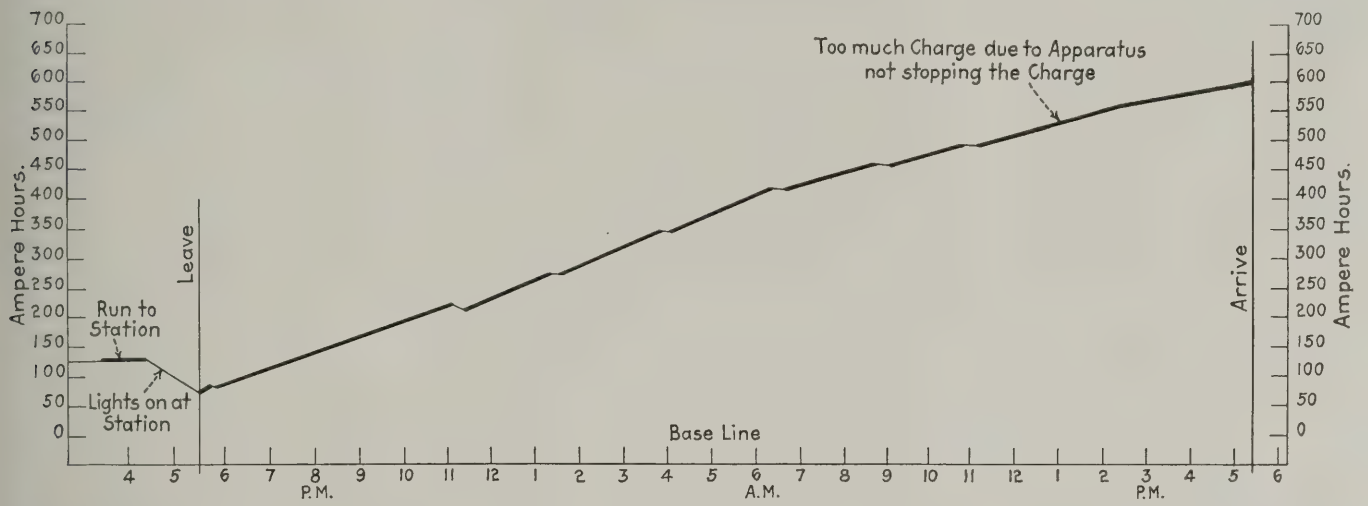


Fig. 6—Graphic Record Showing the Operation of Same Equipment as Fig. 5 but Without Ampere-Hour Meter of Voltage Control of Charge

While standing in the yard there was a capacity of 215 ampere-hours in the battery, as shown in Fig. 4. The run to the station is shown by the heavy horizontal line and discharge now begins as shown by the downward curve of the line. Altogether enroute to and at the station the battery discharged 10 ampere-hours. As soon as the train left the station, the battery started to charge, and this is indicated by an upward slope of the line; since this equipment was set for constant battery current regulation, the upward slope of this line is always at the same angle. If this had been a constant generator current regulator, this degree of slope would have varied depending upon the charging current rate.

During the daylight stops it will be noted that there was no discharge and the light lines, indicating stops, are horizontal. After sunset it will be noted the light lines at all stops slope downward, this indicating a discharge at each stop. As soon as the equipment begins to generate again, however, the curve again begins its upward slope, indicating that the battery is charging at the constant rate of the regulator setting. It will be noted that at 7 p.m., indicated by a cross on the curve, Fig. 4, the battery has reached a full state of charge, and since this equipment was controlled by an ampere-hour meter of the variable resistor type, this meter, like the graphic meter, indicated a zero discharge and thereupon closed its zero contact which stopped further charging of the battery. The battery then simply floated on the line, the generator carrying the load of whatever lamps happened to be in use at the time. It will be noted that there are various stops where a slight discharge occurred, but this was quickly replaced by normal operation of the equipment and the controlling meter again operated to stop further charge when the discharge plus 25 per cent had been put back into the battery.

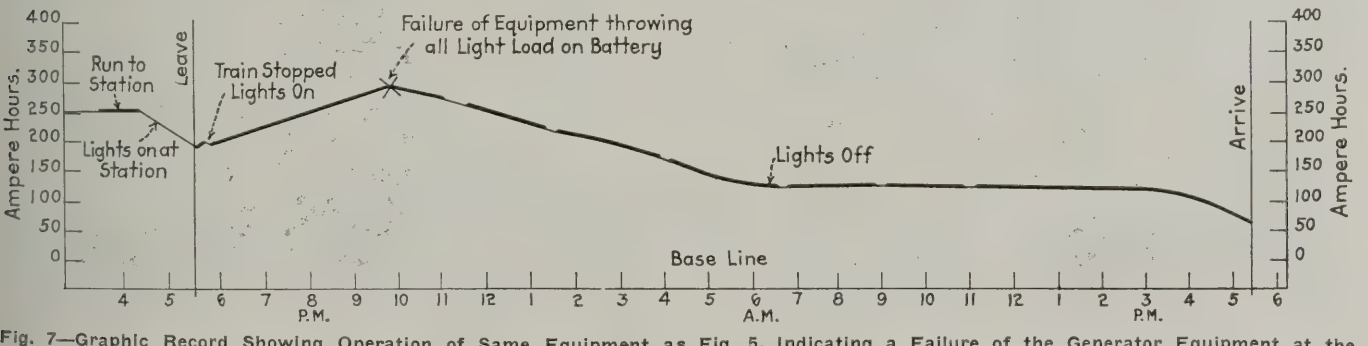


Fig. 7—Graphic Record Showing Operation of Same Equipment as Fig. 5, Indicating a Failure of the Generator Equipment at the Point Marked

Fig. 5 is another chart showing the operation of an axle generator car lighting system with the generator regulator adjusted so as to provide constant battery cur-

rent; the charge given a battery is controlled by an ampere-hour meter of the variable resistor type. As in Fig. 4, we find a very normal condition of affairs with the battery charging normally enroute, a few short discharges at stops, and finally coming to a state of full charge at 2.30 a.m., when the controlling ampere-hour meter operated to stop further charge, and so protect the battery from excessive overcharge. In Fig. 6, however, both the controlling ampere-hour meter and the voltage regulating solenoid were purposely cut out of service and the equipment operated as on a simple constant battery current control. This illustrates, of course, only abnormal conditions such as would be experienced in using a regulator of the constant current type without auxiliary control of charge, or when the voltage regulating feature of the combination current voltage regulators without ampere-hour meter control, or when both the ampere-hour meter and voltage regulation of equipments with the ampere-hour meter control fail to work. In this run it will be noted that a charge of 525 ampere-hours was given a 320 ampere-hour battery, which at the start showed only a 245 ampere-hour discharge. This indicates an overcharge of 280 plus 25 per cent, or 350 ampere-hours, representing the full normal charging rate for nearly nine hours on this single run. When considering the effect of such serious overcharging on a battery, it is not surprising that the average battery life in car lighting service has been so short before the use of voltage regulators giving a taper charge or the controlling ampere-hour meter came into use.

Fig. 7 shows another abnormal condition wherein the equipment failed to generate on the point marked "x" on the curve, due either to lost belt which was not replaced or trouble on the equipment. It will be noted that there is a continual discharge on the battery from this point till the end of the run; this does not follow a straight line, but tapers more to the horizontal as the number of lamps in use is reduced.

The graphic ampere-hour meter is also very useful in recording the effect of tapered charging with the combination current voltage, and also on the constant voltage types of regulation under various conditions of winter and summer operation. Its use is also a big help in determining the proper floating voltage for the battery at various times of the year.

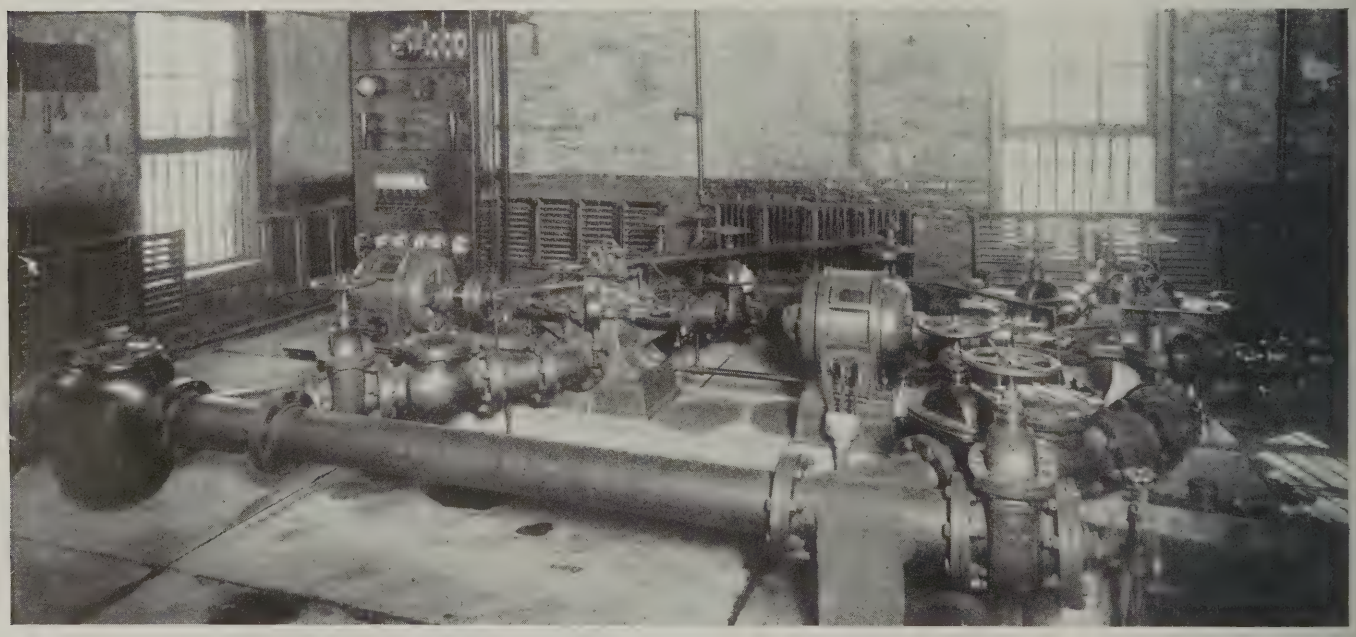
A Modern Electric Pumping Station

By C. R. Knowles

Superintendent Water Service, Illinois Central, Chicago

THE Illinois Central pumping plant at Kankakee, Ill., was recently equipped with electrically-driven pumps, replacing steam pumps and boilers which had become inadequate to supply the increased demand for water. The electrical installation consists of duplicate units, each having a capacity of 30,000 gal. per hour against a head of 130 ft. The pumps are automatic in operation, being controlled by the height of water in the tanks. The former steam plant requires the services of three attendants, while only one is employed in the operation of the electric plant.

The pumps are single-stage, double-suction, horizontal, split-shell, centrifugal pumps with 5-in. suction and discharge. They are bronze fitted throughout with bronze enclosed impellers. The pumps are designed to deliver 500 gal. per min. against a total head of 130 ft., including 15 ft. of suction lift. The motors are 25-hp. horizontal, 3-phase, 60-cycle, 220-volt, 1,750 r.p.m. cross-the-line type, self-starting motors. The motors and pumps are direct connected and mounted on the same sub-base. The control panel is of the Sundh type.



Interior of the Pump House, All the Piping Exposed

The control circuits are shown in the wiring diagram and a list of the equipment on the control panel is given in table 1. The control panel is 84 in. high, 36 in. wide and is made of 1½ in. black marine finish slate mounted on an angle iron frame.

The double-throw, 3-pole switch No. 8 is used to select either motor No. 1 or motor No. 2. The two motors cannot be operated simultaneously. When switch No. 8

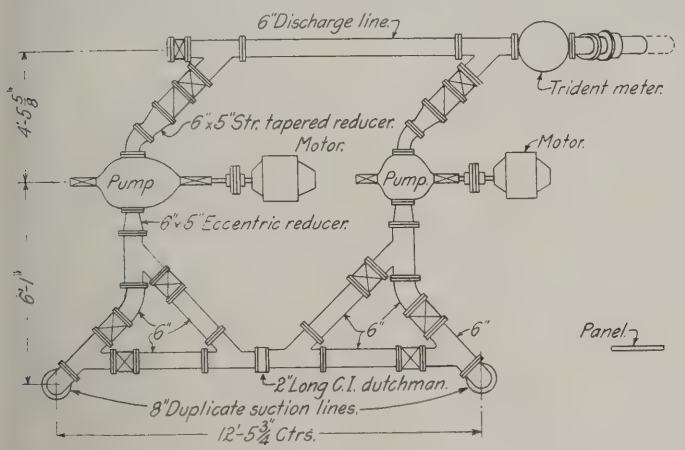
and the main switch No. 1 are closed the motor which has been selected will operate automatically, controlled by the pressure regulator No. 6. If it is desired to start the motor by hand, this can be done with the hand starter No. 9.

TABLE 1

1	3 P. S. T. switch, 200 amp., 250 volts.
2	N. E. C. fuses, 3p, 150 amp., 250 volts.
3	Watthour Meter, G. E. Co., D-6.
4	Press gage, 5" black rim 0.75 lbs
5	Bul. 7,600 relay, 1p, 3 amp., D'W'G F-174.
6	4,900 Press. Reg. DWG D-300.
6a	9P, 7,250 relay to have insulated knob handle.
7	Overload I. T. L. relays.
8	3 P. D. T. KN.SW. 200 amp., 250 volts.
9	3 step, 2 lever hand starter, 150 amp.
10	Resistance (2 steps).
11	7,600 mag. switches, 4 A.C. D-377.
12	Dash pots DWG B-248.
13	Low voltage release coil.

The pumps are fitted with a diaphragm by-pass valve to the suction for automatic priming when operating under float control.

The station was placed in service in January, 1920, and



The Pipe Layout

during the subsequent calendar year 109,368,000 gal. of water was pumped at a cost of $2,154.35 for electricity, or an average cost of $0.0196 per thousand gallons for power only, the current consumption being 66,390 kw. h., at an average cost of $0.0324 per kw. h., the pumping head ranging from 100 to 110 ft.

The cost for current about equals the cost of coal formerly used in the operation of the steam plant, the net saving being equal to the salary of the two men whose services are dispensed with, and which amounts to approximately $2,000 per year.

The operating results for 1920 by months are given in Table 2. The results given are taken from the current consumption as shown by electric meter on the switchboard and water pumped is measured by a current type of meter located in the discharge line.

TABLE 2—STATEMENT OF OPERATING RESULTS FOR 1920

Month	Current consumed	Cost of current	Water pumped
January	5,370 kw.hr.	$174.57	8,950,000
February	5,820 kw.hr.	168.98	9,775,000
March	5,650 kw.hr.	165.92	9,450,000
April	5,440 kw.hr.	162.14	9,190,000
May	4,940 kw.hr.	152.59	8,105,000
June	4,870 kw.hr.	151.12	7,955,000
July	5,430 kw.hr.	161.96	9,018,000
August	4,530 kw.hr.	184.79	7,405,000
September	5,820 kw.hr.	201.71	9,690,000
October	5,840 kw.hr.	202.19	9,720,000
November	6,100 kw.hr.	208.43	10,015,000
December	6,580 kw.hr.	219.95	10,095,000
	66,390 kw.hr.	$2,154.35	109,368,000

The operation of the pumps has also been checked up at various times, the result of a recent test under varying heads and deliveries being shown in Table 3:

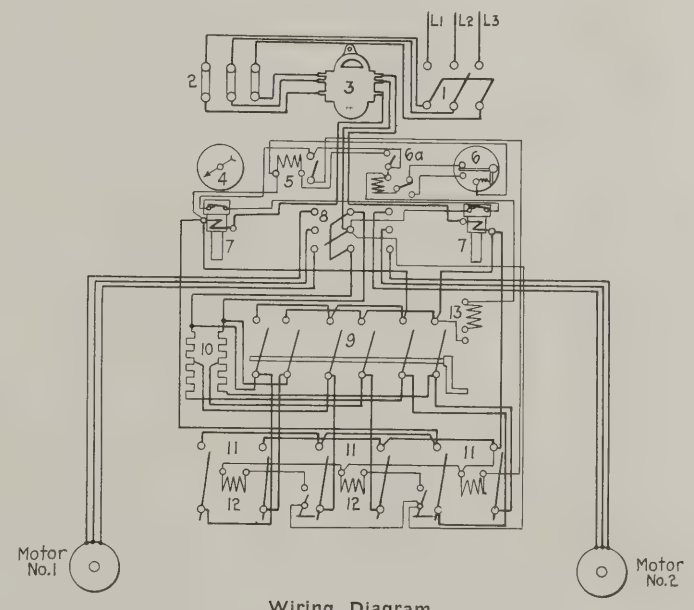
TABLE 3—PUMPING RECORD

Time	Pressure	Suction, inches	R.p.m. pump	Kw. input to motor	Water pumped, g.p.m.
1:25	44.7	16.5	1,790		
1:30	44.7	....	1,790		
1:35	44.7	....	.....		
1:40	44.7	16.5	.....		
1:45	44.7	....	.....		
1:50	44.8	16.5	.....	22.8	592
1:55	....	....	1,765		
2:00	....	....	.....		
2:05	45.2	....	.....		
2:10	....	....	1,745		
2:15	45.3	....	.....		
2:50	45.8	15.5	1,765		
3:00	46.0	....	.....	20.3	520
3:05					
3:10	43.8	16.5	.....	23.4	650
3:35	39.3	20.25	.....	26.3	800

NOTE—To all total heads add 3 ft. for elevation from center of line gage to point of attachment of mercury column.

While running the test given above from 1:25 to 2:15 p. m. the water was pumped into the main or controlling tank, the line across the bridge and all other outlets from the controlling tank being closed. From this test it will be noted that the pump was delivering 592 g.p.m. against a total head of 124 ft., using 22.8 kw. This test shows an overall efficiency of 60 per cent from input through the control board motor and the pump.

The test from 2:50 to 3:00 p. m. was made in the same manner as in regular service, the water meter showing a delivery of 520 g.p.m. against a total head of 126 ft.; the input through the meter being 20.4 kw., or an overall efficiency of 60 per cent. The test from 3:05 to



Wiring Diagram

3:10 p. m. showed a delivery of 650 g.p.m. against a total head of 122 ft., using 23.4 kw., or an overall efficiency of 62 per cent.

The last test shown above was with all valves wide open the suction lift was 20.25 in. of mercury, the total head 116 ft. and the quantity of water handled about 800 g.p.m., with 26.4 kw. input, making an overall efficiency of 66 per cent. The difference appears unusually large, but there is a marked increase in efficiency when a greatly increased quantity of water is handled.

The installation has been entirely satisfactory in every respect and has given no trouble except for brief interruptions to service on account of low voltage.

Power and Lighting Equipment in Railroad Service*

Development and Standards in Electrical Equipment, Use of Motors and Lamps Has Doubled in Five Years

By J. E. Gardner
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THE electrical department of a steam railroad has a varied field in which to work, comprising the mechanical department, the building department, the water service department, in fact the whole engineering department, and it handles both power and lighting installations as well as welding and electric furnace installations. The electrical department, the newest department of a railroad organization, has thus a rapidly growing field for its work, both in importance and in scope. This paper aims to tell of a few of the problems and the newer developments in the electrical field, without attempting to go into many of the technical details.

Electrical welding, perhaps the latest adaptation of electricity to the railroad shop, will not be taken up at this time.

Electricity is being used as the form of energy for various purposes, because it means, in practically every case of its use, a direct economy to the railroad, and this question of economy of operation must be considered in planning any new installation. In most cases, this can be calculated in actual dollars and cents. This may be a saving in coal burned at a power plant, in labor for the operation of a pumping plant or a coal chute, in an increased output from a machine tool or group of tools, or a saving due to the decreased initial investment for a power plant in a case where electrical energy can be purchased at an economical rate. The wonderful convenience of electricity in its many adaptations is not always so easily reduced to dollars and cents, but it is often the determining factor in deciding on the type of an installation.

The reliability of electrical operation is an important factor and it is the aim of the electrical department to make reliability and dependability its first consideration in laying out an installation, including due observance of "Safety First" measures.

The ideal of the electrical engineer is to install equipment that will do the work required quickly, economically, and do this every time it is called upon.

The rapid growth of the electrical industry may be seen from the fact that in 1915 the motors in the United States served by central station power amounted to a total of 6,100,000 horse power, whereas in 1920 they totaled over 12,900,000, an increase of over 100% in five years.

Similarly, the number of incandescent lamps sold per year increased from 4,000,000 in 1890 to 110,000,000 in 1915 and 231,000,000 in 1920, also an increase of over 100% in the last five years.

Alternating Current vs. Direct Current Power

One of the very first considerations in a power installation is the proper type of power to adopt. If power is to be purchased, it will nearly always be found that the power company can supply three phase alternating current, and can supply this at a cheaper rate than the direct current in cases where it can furnish either. In cases where power is to be generated, three phase alternating current is fast becoming the current adopted, and for very good reasons.

For transmission purposes, three phase power is unquestionably the preferable type, as the use of transformers gives the choice of all voltages for any one installation and allows the same power to be efficiently converted to 110 volts for lighting purposes.

The three phase motor, especially the squirrel cage type, has many advantages over the direct current motor

*Abstract of a paper presented before the Western Railway Club.

wherever a constant speed motor can be used. It has no commutator to give trouble, and in the case of the squirrel cage motor it has no moving electrical contacts or brushes whatever, and no rubbing parts except the bearings. The manufacturers have now developed rotors to squirrel cage motors that are almost indestructible, and so long as the bearings are kept properly lubricated and the motor is not improperly overloaded it will run indefinitely without giving trouble.

The control of a squirrel cage motor is of the simplest possible type to operate. The starting of such a motor by hand control consists, in the case of the smaller motors, merely of throwing in a switch, and in the case of the larger motors, of throwing the double throw switch of a compensator. The stopping of such a motor consists merely in the throwing out of the switch, either directly or by means of a push button. Further, this push button, or in fact a series of push buttons, can be located at convenient points for stopping the motor either for its regular operation or in emergency.

In short, the squirrel cage motor is the most rugged and fool proof motor obtainable, and should be used wherever possible. It has, however, the characteristic of lower starting torque than can be obtained from the slip ring motor, which makes the slip ring motor necessary for starting machinery that must start under heavy load, as air compressors, triplex pumps, etc.

The direct current motor has to its credit the variable, or adjustable, speed that can be obtained from it and is used wherever possible, when this quality is of prime importance.

For this reason, many large shops furnish both three phase and direct current, using the direct current where adjustable speed is needed. However, even in such cases the ordinary procedure is to generate three phase current first and convert this to direct current by means of a motor generator set or a rotary converter, so that the direct current immediately becomes more expensive to generate, due to the losses in this apparatus.

Furthermore, alternating current is coming to such universal use that many manufacturers are furnishing sufficient speed changes in their standard machine tools to permit the use of a constant speed motor. In very many cases it is cheaper to purchase a tool with sufficient speed changes to permit the use of a squirrel cage motor than to purchase a tool without such changes but with an adjustable speed direct current motor.

For traveling crane drive, the direct current series motors have the advantage that their light load speed is much faster than their full load speed, which makes the operation of the crane faster when handling light loads or running light.

The use of synchronous motors is to be considered in the case of large motors which run practically all of the time under fairly steady load, as for instance the motors of motor generator sets or motor driven air compressors. This is especially desirable where alternating current is generated at the shop or where the power company furnishing current demands a penalty for low power factor. The use of such a synchronous motor in a power plant will raise the power factor of the plant instead of lowering it, as is often the case when such apparatus is driven by large induction motors. In cases where the alternating current generating equipment has become overloaded it should be investigated to see if the use of a synchronous motor will not overcome the trouble before recommending additional generators.

Motor Bearings

Sleeve bearings are still the standard motor bearings, although a number of manufacturers will furnish their motors with ball bearings when these are desired. The design of a squirrel cage motor makes it necessary that there be very little clearance between the rotor and the stator, so that if the bearings are permitted to wear sufficiently the rotor will rub on the stator, causing a motor failure. This and the deterioration of the stator coils from becoming oil-soaked cause the majority of squirrel cage motor failures. Freedom from these two troubles, together with slightly higher efficiencies, are the arguments in favor of ball bearing motors.

Individual vs. Group Drive

In the days when the machinery in the shop was driven by steam power, the usual procedure was to have one large engine drive all of the machinery in one shop. When these engines began to be superseded by electric motors it was found to be of considerable advantage to divide the shop into various groups handled by separate motors, and in the case of certain machines to drive them by individual motors. In this way it was possible to eliminate a great deal of the friction caused by the large amount of shafting, belts, etc., in the shop, and also to operate part of the shop without the necessity of running all of the shafting. The growing use of traveling cranes for machine shops has aided to develop the use of individual motor drive for machine tools, as this does away with all of the shop shafting. Individual drive also gives the added advantage that the tool can be quickly located in any position in the shop. However, in shops, or in shop bays, not equipped with traveling cranes, and especially for the smaller tools, the advantage of individual drive is in many cases neutralized by the added cost of the necessary motors for such drives.

The horse power of the motors in a shop equipped with individual drive would be much more than in a shop equipped with group drive, and the cost of the motor installation will show a much greater contrast owing to the fact that the smaller motors cost more per horse power than the larger motors. In the smaller railroad repair shops especially, all of the machine tools are not worked to their capacity at the same time. If individual drive is adopted, each motor must be large enough to handle the maximum load on that machine tool, and in the case of reciprocating machines, as planers, slotters, etc., the motor must be large enough or the machine must be equipped with enough flywheel capacity to furnish the momentary energy required to reverse the machine at the end of the stroke. In the case of group drive, all of the energy stored in the shafting and various machines of the shop is available at such an instant, and this fact makes a still greater difference in the horse power required with group drive as compared to individual drive.

Furthermore, with a shop using only alternating current a few motors loaded nearly to capacity will furnish a much higher power factor than a large number of motors carrying light loads. This is of special importance if the shop generates its own electric power.

Consequently, before deciding to adopt individual drive

throughout an entire shop, it must be carefully considered as to whether the additional cost is warranted, as compared with group drive, especially for the smaller machines.

In laying out group drive for a shop, such as is found at a roundhouse point, it is advisable to put certain tools that are likely to be used at any time for emergency work in a group by themselves so as not to necessitate running of a large number of tools during the night.

Standardization of Motor Speeds and Voltages

The size and first cost of a motor decrease as the speed increases, consequently in designing a motor drive care should be taken to see that a motor of the highest practical speed is used.

For gearing or chain drive, the speed of the motor must be selected with care not to exceed speeds in good practice, taking into consideration the size of the motor.

For belt drive, the size of the two pulleys and the reduction of speed permissible with one pair of pulleys determines the motor speed that must not be exceeded. For 60 cycle, three phase motors the speeds must commonly used are no load speeds of 1800, 1200, 900 and 720 r.p.m., with full load speeds approximately 5% less, and a safe plan to follow for a belted motor is to see if a 1200 r.p.m. speed can be used and work as near to this speed as possible without getting too great a pulley ratio.

Basing the price of 1200 r.p.m. motors at $100 for the sake of convenience, the relative price of motors of the various speeds is approximately as follows:

Speed in r.p.m.	Comparative Cost.
1800	$ 77
1200	100
900	125
720	142
600	158

In order to standardize on motor speeds, the manufacturers are furnishing direct current motors with approximately the same speeds as the full load speeds of alternating current motors. It is also, of course, a decided advantage to the motor user to keep the motor speeds as near standard as possible, and this should be considered in selecting motors.

The advantage of a spare motor, and the ease with which motors can be transferred from one tool to another in a shop is increased by the extent that such standardization is perfected.

Another argument in favor of motors of speeds of 1200 or 900 r.p.m. is that they can be more readily purchased.

Voltages should also be standardized as far as possible for the various shops on one railroad. For direct current, 230 volts is beyond doubt the best for power. For three phase current, 220 and 440 volt motors are both used and the majority of the induction motors manufactured can be reconnected for either voltage. For a good-sized shop the cost of copper wire for power circuits is a large item and if 440 volts is used instead of 220, the circuit wires will be half the size, and feeders, when the voltage drop determines the size, can be one-fourth the size. For this reason 440 volts is recommended for a standard.

There are certain communities, however, where power companies furnishing power insist on furnishing 220 volts instead of 440, as they are more interested in standardizing their transformer equipment than in the amount of copper that their consumers use in their wiring. For this reason, 220 volt motors will be used at such places and can be recommended where the power company is furnishing transformers and, having no 440 volt customers, does not carry any spare transformers of that voltage. In case of a motor failure at such a point, a spare 440 volt motor can be reconnected to be used on the 220 volt circuit.

Circuit Breakers and Relays

Every motor must be protected against overload by a set of fuses or a circuit breaker, or its equivalent in the case of relays. When a fuse blows, the motor is shut down until the fuse is replaced, a condition which means a delay, and in many cases a serious delay.

When a circuit breaker throws out it is only a matter of seconds for the operator to throw it in again and have the motor running. For this reason, circuit breakers or overload relays are recommended for use on every electric motor and are well worth the additional cost in time saved. For induction motors overload relays will be used in connection with the compensator, oil switch, or other starting device. In the case of a hand starting compensator, these will not be thrown on the line until the motor is up to speed, but with automatic starters and oil circuit breakers they will be on the line while the motor is starting and using an excess of current over the normal running current. For this reason it is important that relays be provided having a proper time element and one that can be readily adjusted, otherwise the relay will have to be set so high to resist the starting current of the motor that it will not give the proper protection while the motor is running. Also, the inverse time element feature will permit the motor to run under a slight overload for a longer time than under a heavy overload.

Safety Switches

The "Safety First" campaign in all industrial lines has been the means of bringing out many new types of safety switches and safety devices, most of which are commendable. Safety switches mean protection against personal injury, against fire and against power failures. In addition to the safety switches, many panel boards now have the fuses of each polarity or phase in a separate compartment, the different compartments being separated by barriers. Compensators can now be obtained with the relays and no voltage coil complete inside of the same case as the compensator, which adds to the convenience and neatness of wiring. Automatic starters can be purchased complete with enclosing cabinets so that they can be located close to the motor without need of additional protection, and so that a complete conduit installation can be made.

Pumping Plant Operation

The present high price of labor, gasoline, kerosene and coal combine to make electrical operation economical in many pumping plants and coaling stations where electric power is available. In many cases the use of automatic control is the determining factor in reducing the cost of labor for operating a pumping plant. However, no automatic devices are absolutely infallible, and

where hand starting can be operated without great additional expense it is advisable, as it makes it necessary he attendant visit the plant at least once every time the notor is started. Pumps do not always prime properly, umps and motors have to be oiled at regular intervals, earings run hot occasionally, so that it is not fair to ny equipment, however reliable, to expect it to operate lay in and day out without attention.

The control of motor driven pumps may be divided nto three classes:

(a) Hand start and hand stop;
(b) Hand start and automatic stop;
(c) Full automatic control.

A. Hand start and hand stop:

The simplest electric installation in the case of a riplex or similar type of pump is a slip ring motor with ontroller and oil switch. One objection to this equipment as ordinarily installed is that it is not absolutely ool proof, for the reason that after the motor has been topped by opening the oil switch it is possible to throw the switch while the controller is in the full speed osition, and thus throw an excessive amount of current rough the motor. Controllers, however, are on the arket so designed that after the motor has been stopped is impossible to start it again without throwing the ontroller first to the off position, which affords full protection by making it necessary to start the motor in the roper manner.

In cases where a centrifugal pump can be used to advantage a squirrel cage motor can, of course, be used ith hand starting compensator control.

B. Hand start and automatic stop:

The first step to consider in the line of automatic control is whether it is advisable to arrange the equipment so at the motor will stop at the time the storage tank is led. In this way, after the operator has started the otor it will drive the pump until the tank is filled and en stop automatically and not start until the operator rts it again. This automatic stopping of the motor is ually accomplished by the use of a float switch in the nk, or a pressure regulator connected to the pump discharge line, operating in either case through the noltage coil of the oil switch or compensator. In cases ere the water tank is near the pump house and ere the ice conditions are not severe in winter, the at switch located in the top of the water tank is ferable. In certain other cases, however, it is adable to use a pressure regulator. When this is used, e must be taken to protect it against the surge that urs in the pipe line whenever the pump is stopped or rted. This surge can be largely eliminated by conting the pressure regulator to a reservoir partly filled h air, this reservoir being connected to the pipe line ough a restricted opening. The use of a pressure ulator is to be avoided wherever there are water es connected to the pump discharge line.

Full automatic control:

he next step is full automatic control obtained ough the use of an automatic starter controlled by float switch or pressure regulator. Upon investiing the different types of automatic starters on the ket, it will be found that they work under two difnt systems. The first type speeds up the motor as the amount of current flowing through the motor decreases. The second type speeds up the motor through a definite time interval. Theoretically, the first of these types is correct, but the writer's experience has been that the second type, where the starting is based on the time element, is a more reliable type in the case of pumping plants, which are oftentimes located some distance from the power plant, and where voltage conditions are not always uniform. With this type of control, there is no danger of the controller staying in the starting position owing to low voltage or to the fact that the motor starts up unusually hard owing, perhaps, to the fact that the operator has tightened up the packing glands on the pump more than he should, whereas similar conditions on the other type of starter may cause it to burn out.

Wherever the float switch or pressure regulator is used, a single pole double throw switch located near the motor starting apparatus is recommended. By connecting up this double throw switch so that when it is open the float switch circuit is open, when it is thrown to one side the circuit is made through the float switch, and when it is thrown to the other side the circuit is short-circuited, cutting out the float switch control entirely, the attendant can test out the apparatus regardless of whether the water tank is full or empty, and can operate the motor by the use of this switch in the case of failure of the float switch through ice in the tank, which in some localities is quite liable to occur.

In the case of the most important water stations, duplicate equipment is recommended for protection in emergency, and where such stations are operated by automatic control, a hand controller is recommended in addition to the automatic controller, this being so connected that reversing a double throw switch cuts the motor control on either the hand controller or the automatic starter, and disconnects the other entirely so that it can be taken out for repairs without shutting down the plant. The writer has installed this equipment in three important pumping stations, and its value in time of emergency has been well proved.

After making a study of various pumping plants, the following data sheets have been worked up to be filled out by the inspector to determine the relative cost of operating the plant by the use of combustion engine or steam power, and by the use of electric motor:

PUMPING PLANT DATA

Location.....

Date.....

ELECTRIC POWER:
Name of power company.
Power company representative and address.
Distance of present line from pump house.
Will power company construct line free of charge?
If not, what will this cost?
What voltage, phase and cycles? (440-v.—3-ph.—60-cycle pref.)
Will power company permit squirrel cage motor?
Will power company furnish meter?
Rate for power.
Terms for off peak pumping.
Discount for 2,300 volt service.
Has power company reliable 24 hour service?
Is full automatic control necessary?
Could pump be operated economically by starting by hand and stopping automatically?
Float switch or pressure control.
Details of control circuit.
Who would oil pump motor, etc.?

It will be noted from these data sheets that the relative economy of the different types of operation is determined by calculating the comparative monthly operating costs, as this is the only accurate way by which the cost of electric operation may be compared with the

cost of operation by combustion engine or steam boiler and pump.

Automatic Control for Shop Motors

Automatic control is slowly being introduced into the railroad machine shops for controlling certain machine tool motors. The arguments in favor of automatic control are that it enables any operator to start the motor properly, that the motor control may be placed where most convenient to the operator, and that with direct current motors dynamic braking may be used to stop the motor almost instantaneously when necessary.

PUMPING PLANT DATA

Location.....

Date.....

1. Gasoline or kerosene engine.
   - Make of engine and pump.
   - Horse power of engine.
   - Type of pump.
   - Single or double acting.
   - Cylinder diameter of pump. In.
   - Stroke of pump. In.
   - Gear ratio.
   - Average speed of pump. r.p.m.
2. Steam pump.
   - Make and kind.
   - No. of water cylinders and diam. In.
   - Actual length of stroke. In.
   - Average speed r.p.m.
   - Boiler—Kind and size.
   - Average steam pressure.
3. Electric motor proposed.
   - h.p. of motor.
   - Speed. r.p.m
   - Can present pump be used?

PUMPING PLANT DATA

Location.....

Date.....

	Present.	Proposed.
Water used per day, max., gallons		
Water used per day, ave., gallons		
Water pumped per minute, gallons		
Flow of well per minute, gallons		
Hours pumped per day, ave.		
Average head: Discharge (static), ft.		
Suction, ft.		
Friction, ft.		
Total, ft.		
Kerosene or gasoline used per hr., gallons		
Water h.p. $\frac{\text{Gals. per min.} \times \text{T'l Hd., Ft.}}{3957}$		
Brake h.p. Water h.p. ÷ Pump Eff.		
Motor Input.—kw. hr. $\frac{\text{Brake h.p.} \times 746}{\text{Motor Eff.}}$		
Brake h.p. hours per month. For engine		
Motor kw. hr. per month. For motor		

PUMPING PLANT DATA

Location.....

Date.....

Monthly Operating Costs:	Present.	Proposed.
Kerosene, ...gals. per month @ c		
Gasoline, ...gals. per month @ c		
Lub. oil, ...gals. per month @ c		
Cost of delivering oil to pump house		
Coal, ...tons per month @ $		
Coal frt. from.....@ $.....per ton mi.		
Coal teaming and unloading at pump house		
Electricity, ...kw. hr. @ c		
Supplies, per month		
Labor, ...pumpers @ $		
Repairs .....Ave.		
Overhead charges		
Depreciation, ...%		
Interest and taxes, 6% on value per year		
Total monthly cost		
Cost per gallon pumped		
Total cost		

In the case of direct current wheel lathe motors an added argument is that the motor may be momentarily slowed down by the means of push button control at times when the tool strikes a hard spot on the tire.

The reversing planer motor is a recent adaptation of automatic control, which is successfully used to speed up the operation of planers both for large and small work. For this equipment, a special motor is used that will stand starting, stopping and reversing at each stroke of the planer. With this control a great time saving is made by the readiness with which the cutting speed or the return speed may be regulated, each independently of the other by elimination of belt slip and by the quickness with which the operator can start or stop the motor either in the regular course of its duties or while setting up work.

Elevator Control

Automatic control is now being successfully used to operate both passenger and freight elevators. One serious disadvantage in the use of automatic control for freight elevators has been that if the car was adjusted to stop at the floor level when carrying a heavy load, it would not stop at the floor level when carrying a light load, making it hard to handle trucks in and out of the elevator. Elevator equipment can now be obtained, however, having a small motor driving the armature of the main elevator motor at slow speed through additional gearing, and by using special leveling cams at each floor level so that when the car reaches the floor at which it is to stop the main elevator motor stops and the small leveling motor then picks up the control, brings the car absolutely to the floor level, and holds it there. With the present high price of labor, such a device often means considerable saving.

Electric Trucks and Tractors

The use of electric tractors for freight house and similar work has brought considerable saving to the railroads and has grown rapidly during the last eight years. Many new types of storage battery tractors have been developed as well as new methods of freight handling. The usual method of handling freight at a freight house where electric trucks are used is to load all of the freight on four-wheel trucks instead of the usual hand trucks and use an electric tractor to haul trains of these trucks about the freight house as necessary. As the average freight house is open only in the daytime, all of the night is available for charging the storage batteries for these trucks. In houses where the trucks are in use most of the day, batteries are given a boost during the noon hour to insure their being in condition for the rest of the day. This is important for the reason that in an outfreight house, especially, the heaviest work on the electric trucks comes near the close of the day when the batteries are partly discharged.

In selecting electric truck equipment care must be taken first to see that the electric tractor is of the proper type and size to do the work, and that it is has the proper size battery of the best type available, considering the kind of service; also that the charging plant is sufficiently large to enable the trucks to be given a boost during the noon hour at a charging rate considerably higher than normal. In case alternating current is the only kind available at the freight house, motor generator sets or rectifiers must be used to charge the truck batteries, and care must be taken to see that any estimate on the cost of equipping a freight house with electric trucks includes this item as well as the electric trucks and the four-wheeled trailers. Where 110-volt direct current is available and several trucks are in use, it will generally prove more

advisable to charge the batteries in series upon the 110-volt circuit than to use motor generator sets.

If the trucks are used on which the storage battery can easily be changed, it is sometimes advisable to furnish extra batteries so that these can be charged during the daytime while the trucks are in service. In the case of baggage trucks at a busy terminal, it is often necessary that each electric baggage truck be equipped with two sets of batteries so that the truck itself can be kept in service during the full 24 hours.

Special types of electric trucks are available for use around shops, one of the most recent adaptations being the truck which has a lifting platform. When using such trucks, the material to be handled is loaded on small skids placed on the floor and the electric truck is equipped with a low platform that slides under the skid. This platform is then raised up slightly through the use of the truck motor so that the skid is raised from the floor and can be carried by the electric truck to the place desired.

Lighting

The rapid development of incandescent lamps within the last few years has added entirely new possibilities in the electric lighting field, and the intensity of illumination which is recommended to be supplied has increased year by year. From a railroad point of view, we see in this two separate phases. First, utility lighting in shops, roundhouses, offices, yards, etc., where the lighting is for the advantage of the railroad employees. Second, lighting that must have a certain decorative value, as railroad trains, stations, and such places where the lighting is for the benefit of railroad patrons as well as railroad employees. A study of the situation shows that in practically every case the amount of light furnished is much greater than it was a few years ago. In the case of shop lighting, yard lighting, etc., it has been proved that by furnishing general illumination of sufficient intensity, the efficiency of the workmen is greatly increased as well as the quality of the output and the protection against accidents. Until recently it has been the custom to employ mechanics for night work at roundhouses, etc., and expect them to do good work with the light of an oil torch. The recent increased cost of labor brought out the fact faster than it would otherwise have been brought out that it is absolute economy to furnish proper lighting at such points, especially where work is being done all night long. The cost of electric lighting is a small item compared to the total cost of operating a shop, so that the question must be carefully considered at each shop as to whether sufficient illumination is provided. A record of eight years ago shows that as low as two foot candles was recommended at that time for machine shop lighting, whereas the latest recommendations are from five to ten foot candles. By furnishing general illumination of sufficient intensity the use of portable cords can largely be done away with. A portable cord has always been an expense to maintain, and the small lamp used with the portable cord, as well as the lamps used for drop lights, have always been a source of expense due to breakage and theft. By lighting the shop with large lamps located in suitable reflectors at a considerable height above the floor, trouble due to lamp breakage, theft and lamp cord maintenance is done away with and at the same time much better lighting is obtained.

The only recent important addition to the available lamps is the bowl enameled gas filled lamp. This lamp is designed for use in the standard reflectors, the enameling being to dispense with the glare caused by a bare gas filled lamp when placed low enough to be in the line of vision.

Yard Lighting

The use of large Mazda lamps has made possible lighting of large outdoor areas by the use of flood lights. A few years ago the method of lighting a hump yard, or in fact any freight yard, was to install rows of arc lights between the tracks or suspended over the tracks. At a later date the Mazda lamp superseded the arc lamp, still using the large number of lamps distributed through the yard. Now, by the use of a few flood lights located at proper points, much better illumination can be obtained and the cost of maintenance reduced. For a hump yard, a flood lighting tower located at the top of the hump will enable the car riders to see ahead of them almost as distinctly at night as in the daytime, and thus permit them to carry their cars as far from the hump as possible and yet avoid damage to the cars or contents.

For the best results, these flood lights should be located not less than 50 feet from the ground and preferably at least 75 feet. For lighting the larger areas, 1000-watt lamps should be used, and the reflectors of the flood lights should be mirrored glass or metal that will not easily tarnish. This latter is a point that must be carefully considered, as the average flood light does not get the attention that a locomotive headlight reflector receives. In cases where one 1000-watt lamp is not enough to light a given area, the usual practice is to install a battery of several of these lamps. By slight changes in the focusing and position of the different reflectors, the light can be distributed over the proper area. The use of flood lights has the decided advantage of leaving the space to be lighted largely free from poles and overhead wires. In the case of a cinder pit, especially where the cinders are handled by a clam shell, the lighting has always been difficult and hard to maintain. The use of flood lights placed at cord has always been an expense to maintain, and the small lamp used with the portable cord, as well as the lamps used for drop lights, have always been a source of expense due to breakage and theft. By lighting the shop with large lamps located in suitable reflectors at a considerable height above the floor, trouble due to lamp breakage, theft and lamp cord maintenance is done away with and at the same time much better lighting is obtained.

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Mr. Gardner's paper was concluded with a resumé of present practice in train lighting.

Discussion

E. W. Jansen, electrical engineer, Illinois Central, has mentioned that in one of the freight houses on the Illinois Central there are eight electric tractors that handle an average of 1600 tons per day. The average train is 12 trailers, but 20 trailers may be handled by one

tractor. The freight house is long and narrow, extending from South Water street to Madison street, about 40 car lengths. Therefore, the use of tractors and trailers is especially applicable to this situation.

The batteries of the electric baggage trucks are given a two-hour charge after the morning trains leave and a two-hour charge during the afternoon, and are charged during the latter part of the night. By this program full time service is obtained from the truck by the use of only one battery.

Electrically operated air compressors have recently been installed in some of the freight yards to charge the train lines. These motors are automatically controlled, cutting out when air pressure is 90 lbs. and cutting in at 75 lbs.

In stations where three or four pumps or compressor motors are located, a practice has been made of using double throw switches and circuits so that only certain motors can be run at one time; by such an arrangement a lower maximum power demand and corresponding lower power rate is secured. Of all motor troubles, 90 per cent are due to overloading, which is especially true at coal elevators.

C. J. Causland, chief electrician, Pennsylvania, said that in one of the freight houses on the Pennsylvania there are 32 elevators which handle 2,500 to 3,000 cars of merchandise per month, on a 22 ft. lift. In spite of this immense amount of work accomplished the power consumed by the elevator motors is only one-fourth of that used for electric lighting of this freight house.

Ernest Lunn, chief electrician, Pullman Company, spoke on the subject of train lighting as follows: "Mr. Gardner did not mention the electric floor lamps in the Pullman cars. For several years we tried floor lamps to illuminate the passageway after other lights were turned off at night. However, it was found that a white light gave too much glare, disturbing occupants in lower berths. One of the electricians at St. Louis tried a green globe which eliminated the glare. This particular car came to Chicago and a newspaper reporter had an article in the morning paper about it before the head of our car lighting department knew anything about it. The traveling public is quick to note any change in the intensity of illumination. We find that 3 to 4-ft. candles are required to give satisfaction.

C. E. Fuller, superintendent motive power, Union Pacific, said the Union Pacific has used the head end system from the first. Perfect satisfaction is given by this system, and light failure percentage is practically zero. The position of the railroad is rather peculiar in that the passenger trains are delivered to it from the east and west made up and go through as units. As the connecting roads use the head end system, the Union Pacific, of course, does the same. It is his opinion that the head end is cheaper to install and maintain, but he said the axle system would be given consideration on a new installation. A changeover has been considered many times.

Mr. Fuller asked Mr. Gardner if it was more economical to use group drive than individual drive for shop machinery.

Mr. Gardner answered in the affirmative, stating that by means of the group drive the motor is run at nearer the maximum load a greater part of the time.

Mr. Fuller then asked if the cost of belts, shafting, etc., would not balance the cost of power saved.

Mr. Gardner said the group drive is cheaper for small tool bays and the power saved would more than pay the difference.

Mr. Jansen continued the subject by saying that about two years ago they had an engine failure in one of the large shops on the Illinois Central, and a 100 hp. motor was used to handle the load temporarily. One noon a test was made which proved that the operation of the line shafting, loose pulleys and belting consumed 50 per cent of the total power required.

Mr. Fuller added the information that in one of the old shops on the Union Pacific there was a main shaft 800 ft. long which consumed 60 per cent of the total power required.

G. F. Bunn, General Electric Company, said the question of group or individual drive is a question to be solved for each shop. A good program is to group the drives in such a manner as to use the same sized motors throughout. One spare motor can then be used to replace any motor that fails. The railroad, he said, might well use the engineering talent offered by the manufacturers, who are glad to furnish engineers to study special problems before an equipment is purchased.

L. S. Kinnaird, superintendent of motor power, Chicago & Eastern Illinois, said long shaft drives require as much as 62 per cent of the power, while short shaft drives use as low as 15 per cent. In modern shops, belt and shafting are eliminated to permit the use of overhead cranes; however, on light machines this need not be considered. It is considered more economical to group the smaller machines and in this way keep the motor at nearly load.

Mr. Gardner added that in one of the shops on the Burlington, when motor drive was installed the line shafting was lined up on adjacent drives so that in case of one motor failure the shafting could be connected and run from the next motor.

Mr. Jansen concluded the discussion by saying that in roundhouses and shops plenty of receptacles of the safety type should be provided to eliminate long portable connections for welding, riveting and portable drilling machines.

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The Architecturally Beautiful Railway Station at Metz, Lorraine France—Formerly Metz, Germany

Electrical Interference by Propulsion Circuits*

The Extent to Which This Trouble Occurs on Communication and Signal Lines and the Steps Taken to Overcome It

RECOMMENDED practice for eliminating, so far as practical, interference with telephone, telegraph and signal lines caused by propulsion currents and adjacent transmission lines, was the subject upon which one of the sub-committees of the Committee of Electricity reported at the recent convention of the American Railway Engineering Association at Chicago.

The activities of the committee during the year have been based primarily on the securing of information requested by a questionnaire framed as follows in order to obtain basic general data from which it is hoped that the committee may later draw conclusions which will be recommended to the Committee on Electricity, and through them to the association for approval:

1. Inductive or electrical interference from transmission and distribution systems on telegraph, telephone and signal circuits.
   (a) Under normal conditions,
   (b) From short circuits or grounds.
2. Electrical interference as affecting the safety of employees and the public, with special reference to the kind and extent of trouble experienced.
3. What electrical interference troubles have you been able to trace to electrolytic conditions?

In connection with the answers to the above questions, it is desired that complete and detailed data as to interferences, with reference to the specific kind of trouble experienced, be submitted with a view that the committee may analyze and tabulate the answers submitted by the railway company; and in submitting the above data, the committee desires that the method employed to overcome these interferences be set out in detail, both in connection with the power systems, the railway telegraph and telephone systems, and the commercial communication systems.

It should be realized that, in order to make an intelligent survey of the data submitted, each railway should forward general information as to the type of installation of electrical apparatus, track construction, local climatic conditions, nature and amount of traffic, and method of controlling power circuits; and the answers should be accompanied by diagrams showing railway circuits and parallel circuits, as far as possible.

The above questionnaire was forwarded to the New York, New Haven & Hartford Railroad, the Pennsylvania System, the Long Island Railroad, the Norfolk & Western Railway, the Southern Pacific Company, the Great Northern Railway, the Erie Railroad, the Chicago, Milwaukee & St. Paul Railway, the New York Central Railroad, and the Public Service Railway (New Jersey).

The information which has been received in answer to the questionnaire to date summarize as follows:

New York, New Haven & Hartford Railroad

The electrified zone of the New York, New Haven & Hartford Railroad extends between New York and New Haven, a distance of about seventy-two miles, of four-track and six-track railroad. Both passenger and freight service is handled electrically, and the traffic is very dense, especially during the early morning and late afternoon hours.

The installation is single-phase, eleven-thousand volt, twenty-five cycle, fed from one power plant, at Cos Cob, with an auxiliary feed-in plant at West Farms.

Auto transformers with a ratio of 1 to 2 at the power stations step up the voltage from 11,000 volts (at the generator terminals) to 22,000 volts. The center point of these transformers is grounded to the rail; one terminal is connected to the trolley wires, and the other to

*Abstracted from the report of the Sub-committee on Electrical Interference presented at the 22nd annual convention of the A. R. E. A., at Chicago, March, 1921.

feeders. The voltage between trolleys and feeders is thus 22,000 volts and between feeders or trolleys and ground only 11,000 volts.

At various points along the right-of-way, at intervals of approximately four miles (dependent on the load conditions), auto transformers are connected between the trolley and feeder phases, the neutral point of these auto transformers being connected to the rail.

The system is thus virtually analogous to the common Edison three-wire system, the load being balanced through the line transformers. The benefits of 22,000-volt transmission with 11,000-volt distribution are thus obtained.

In addition to the main line electrification, there is a short stub-end section of single-track branch line, fed from the main line, which has been experimentally equipped with "boost transformers." The primaries are connected around section breaks in the trolley and the secondaries around insulated joints in the rails. These transformers act to keep the return current in the rails and have been successful in eliminating interferences from induction. The system is similar in principle to that applied in connection with the Pennsylvania Railroad (Philadelphia to Paoli) and Norfolk & Western Railway electrification.

The communication circuits are cabled in the Electrified Zone.

In order to conform to the requirements of the commercial companies and thus to allow connection with commercial switchboards, this cable line was built with a minimum separation of ten feet from any high tension circuit, and no aerial crossings over or under high tension lines were allowed.

The cable is made up of 45 pair, paper insulated, lead-covered No. 10, No. 13 and No. 16 gage conductors. The lead sheath is thoroughly grounded at frequent intervals which eliminates all trouble from electrostatic induction. The total distance is seventy-two miles, fifty-six miles of which is aerial construction. Where there are physical high-tension crossings or where the right-of-way is so restricted that the required clearance is not obtainable, the cable is run in underground conduit. The aggregate length underground is sixteen miles.

In the cable there are the following classes of telephone service:

(1) Train dispatching circuits, equipped with selectors.
(2) Load dispatcher (power director) circuits, similarly equipped.
(3) Tie lines for handling general business between New Haven and New York, and from each of these points to intermediate private branch exchanges located at Bridgeport, Stamford and Cos Cob, all connected with commercial outside circuits.
(4) Local telephone circuits connected with all signal bridges more than 1000 feet distant from towers or stations.

The train dispatching circuits between New Haven and New York are No. 10 non-loaded circuits. Those operating between New York and South Norwalk and the Load Dispatcher's circuits east and west of the Cos Cob power plant are No. 13 non-loaded circuits. The telephone tie lines between New York and New Haven, handling connections between New York and Boston and other points north and east of New Haven, are medium loaded No. 13 gage.

The tie lines from New York to New Haven and intermediate private branch exchanges are No. 16 gage, medium loaded. The local power circuits are No. 16 gage non-loaded.

Under normal operating conditions all classes of these telephone circuits are quiet, and no trouble of any kind is experienced. However, on occasions of heavy short circuits on the traction system, so-called "acoustic shocks" have been experienced, and in order to minimize these, drainage coils have been installed at various points along the line, these coils consisting of resistance or condensers in series with retardation coils.

Occasional trouble due to high ground potential is experienced during especially severe short circuits in the traction system.

Repeating coils have been installed at each of the private branch exchanges between the cable conductors and the switchboards. The protection on the line side of the repeating coils is the same as that used at way stations on the dispatching circuits (2,000-volt), while 350-volt protection is installed on the switchboard side of the repeating coils.

Loud-speaking receivers are being installed in the dispatcher's offices where acoustic shocks present the greatest difficulty.

Active tests are being made in connection with both the new telephone cable and the high tension transmission system, with a view to obtaining a quantitative analysis, and much valuable data is being collected in connection with these tests.

No difficulty has been experienced affecting the safety of employees or the public, except the above mentioned occasional acoustic shocks.

The electrified zone runs through a particularly thickly settled district with trolley lines paralleling the railroad the entire distance. Some electrolytic trouble has been noted in water pipes and lead-covered cables. This, however, is due entirely to outside stray currents and no difficulty has been noticed in connection with the A.C. traction circuit.

No trouble which can be charged to induction has been experienced in connection with the automatic signals.

Pennsylvania Railroad

Paoli Electrification.—The Paoli electrification extends for a distance of 21.3 miles from Broad Street, Philadelphia. Power for the operation of the system is obtained from the Philadelphia Electric Company and delivered to the Arsenal Bridge Substation at 13,200 volts, 25 cycle, three phase. At the Arsenal Bridge Substation, which is about a mile west of the electrification, the power is stepped up to 44,000 volts single phase. Step-up transformers are Scott connected, one phase of the high potential side supplying power for the Paoli electrification and the other side for the Chestnut Hill Branch.

There are three step-down substations for supplying power to the Paoli electrification as follows:

West Philadelphia.
Bryn Mawr.
Paoli.

At the above substations the 44,000-volt power is stepped down to 11,000 volts and supplied to the trolley system.

At the Arsenal Bridge substation the middle point of the 44,000-volt windings on the step-up transformers is grounded through a grid resistance which limits the flow of current in case of grounds on the 44,000-volt transmission lines.

The trolley system is sectionalized at each substation.

Booster transformers were installed to prevent the leakage of current from the rails into the earth. The primaries of these transformers are connected across section breaks in the trolley system and the secondaries are connected across impedance bonds used in connection with the signal system. It was found that the booster transformers were of little value and practically all of them have been removed.

All telephone and telegraph circuits are underground.

Tests made showed that under operating conditions it was desirable to provide some means for limiting the amount of current which would flow through relays on the telegraph circuits causing the relays to chatter. A comparatively simple remedy was found in the use of resonant shunts, and with them complete protection with induced voltages as high as 120 volts was provided. These shunts operate also successfully with composite and duplex Morse circuits and with printing relays. The reactance and capacities making up the resonant shunt are so selected that the shunt is resonant to 25-cycle current, thus providing a bypass for current of this frequency and preventing damage to the relay.

On local or way circuits it was found that anti-resonant shunts located at the ends of circuits afforded the desirable protection. This shunt operates as an impedance to 25-cycle current, thus limiting the flow of current through the relay.

In order to provide against the receiving of shock by persons using telephone instruments all metal parts of instruments with which persons could come in contact are insulated. Wooden platforms are provided on which persons using telephones may stand. Magnetic telephone wall sets are used. The protector used on this circuit is reliable between 350 and 700 volts.

Relays are installed in exchanges to balance up circuits to prevent noise. No electrolytic troubles have been experienced.

Chestnut Hill Electrification.—The Chestnut Hill electrification extends for a distance of 13.2 miles from Broad Street. Power is supplied from the Arsenal Bridge substation to West Philadelphia substation, 1.1 miles from Broad Street. The North Philadelphia substation is 4.3 miles from West Philadelphia and the Allen Lane substation is located 5.34 miles from the North Philadelphia substation. These substations are supplied with 44,000-volt single phase power, the same as the substations on the Paoli electrification.

Before the Chestnut Hill branch was put into operation extensive tests were made in conjunction with the telephone and telegraph department of the railroad and the American Telephone and Telegraph Company. The result of these tests was that the installation of booster transformers was unnecessary, as sufficient protection against interference could be obtained by the use of the same apparatus as was used in the case of the communicating circuits on the Paoli electrification. The Chestnut Hill branch has been in operation for over two years and no trouble has been experienced on telephone and telegraph circuits.

The telephone and telegraph service at Philadelphia is excellent and, in fact, much better than it is in some locations where there is no electrification. It is not considered that the electrifications into Broad street are the cause of any interference to the communicating system.

No trouble which can be charged to induction has been experienced in connection with the automatic signals.

During the last year and a half considerable trouble has been experienced on communicating circuits between Camden and Trenton. The railroad between these points is operated by steam, and is paralleled for the greater part of the way with a Public Utilities transmission line operated at 26,000-volt, three-phase, 60-cycle. Power is supplied to transmission lines from the power station about midway between Camden and Trenton. In a great many instances grounds on the transmission lines have caused considerable trouble on the railroad company's communicating circuits. Protectors have been broken down, fuses blown and in some instances operators have received a bad acoustic shock. Trouble has also been experienced on the Postal Telegraph Company's lines. The cause of this trouble is being investigated and it is expected that the installation of suitable relays to provide a very rapid opening of circuit breakers will minimize the trouble experienced.

No electrolytic troubles have been experienced.

New York Terminal.—The power for the operation of the Pennsylvania system is supplied from the Power House in Long Island City to four (4) transformer substations similar to those of the Long Island Railroad. The transmission lines are cabled to the substation on the Jersey side and beyond this they are open wires and are not transposed. The telephone and telegraph circuits are cabled to the same point and beyond this they are carried on a pole line as open wires on the opposite side of the right-of-way. No trouble is experienced on the communicating circuits under normal operation and in cases of short circuits or grounds on the transmission lines there has not been any trouble. Considerable trouble has been experienced from electrolysis. Several cables have become defective and it is necessary to constantly watch the potentials of cable sheaths and underground structures to prevent damage. There has been no interference with the signal system.

Long Island Railroad

The power system of the Long Island Railroad consists of three-phase alternating current transmission at 11,000 volts, 25 cycles, rotary converter substations converting this A.C. power to D.C. power at 675 volts and the distribution systems consisting of third rail positive circuits and track rails bonded for return circuit. Power for the entire system is supplied by the Power House of the Pennsylvania Railroad in Long Island City, which Power House also furnishes power for the operation of the New York terminal of the Pennsylvania Railroad. There are 15 rotary converter substations at various points about 3 to 8 miles apart, the most distant substations being located a little over 20 miles from the power house.

The transmission system consists of three-phase circuits operated at 11,000 volts. The neutral of the system

is grounded at the power house through a resistance, but is not grounded at any other point. The voltage from each phase to neutral is, therefore, approximately 6,000 volts. The feeders of the transmission system are both overhead and underground and for the most part consist of 250,000 c. m. copper conductors. The underground feeders are three conductor paper insulated lead-covered cables.

The overhead feeders are not transposed. In some cases, the three conductors of a feeder are spaced to form an equilateral triangle. In other cases, the three conductors are arranged in vertical formation, one above the other.

The distribution system consists of over-running contact third rail, the majority being of high capacity equivalent to 1,600,000 or 2,400,000 c.m. The direct current feeders are usually short, being tapped into the third rail directly opposite the substations. The track rails suitably bonded with copper bonds are used for the return circuit.

The transmission feeders are paralleled by telegraph and telephone circuits throughout almost their entire length. Where aerial construction is used, the transmission circuits are carried on a pole line on one side of the right-of-way and communication circuits on a pole line on the other side of the right-of-way, the distance between the two lines varying from 30 feet, with a single or two track right-of-way to 60 or more feet with a four-track right-of-way. In one section, for a distance of approximately four miles, the communication circuits are carried on the same pole line as the transmission circuits. The telephone circuits in this instance are not brought into the main telephone exchange simply as a matter of precaution. The open-wire telephone circuits are transposed at regular intervals, usually about 8 per mile. In some cases telephone and telegraph cables are routed in the same conduit system as transmission cables.

Under normal conditions, there is no perceptible interference of an inductive nature on communication circuits. There are occasional troubles due to circuits becoming unbalanced, due to one cause or another, but these are usually of short duration. The fact that almost the entire load connected to the transmission system consists of three-phase rotary converters tends to keep the transmission system in balance.

Under abnormal conditions, such as short circuits or grounds on the transmission system which are of sufficient proportion to trip out one or more high tension feeders, the unbalanced condition of the transmission line affects the communication circuits to some extent. The chief cause of this trouble seems to be due to the neutral being grounded at the power house. When a ground occurs on a phase of the transmission system, the current seeks a return path through the ground to the power house. In numerous cases it has been found that the potential of the ground has been raised near the scene of trouble to such an extent that the protective devices on the communication circuits are broken down and ground current takes this means of returning to the power house. At times of short circuit or ground excessive noise is always manifest in the telephone circuits caused by induced currents. These currents also ring bells, throw the drops on the switchboards, cause chattering of telegraph relays, etc. When ground is removed through opening of power circuit breakers, conditions again become normal.

No trouble has been experienced on the communication circuits due to electrical interference from the distribution system.

No troubles have been experienced from electrical interference which have affected the safety of employees and equipment.

Considerable trouble has been experienced through failure of paper insulated telephone cables as a result of electrolytic action. These cables run in a conduit system which parallels the electrified tracks for a distance of over eight miles. For part of this distance the conduit system is also paralleled by large water mains. Other water mains as well as tracks of trolley roads cross the conduit system at frequent intervals. Troubles from this source have been reduced through frequent electrolytic tests and surveys and the installation of drainage bonds, etc., but all of these have not yet been entirely successful in overcoming the electrolytic action.

Norfolk & Western Railway

The Norfolk & Western Electrification is 11,000-volt, single-phase, 25-cycle, using overhead catenary trolley with 44,000-volt duplicate, single-phase transmission circuits feeding power from a steam power house to five substations located at intervals from 6 to 8 miles apart. The electrified territory extends from Bluefield west to Vivian, about 30 miles, with two short branches north and south from Bluestone to Pocahontas and Clift Yard near Simmons. The main power house is located at Bluestone. The line generally is double track with stone ballast, and bonding is maintained in first-class condition. The local climatic conditions are generally favorable as the electrification is located about 2,500 feet above sea level where the air is reasonably dry and free from damp, salt atmosphere.

The traffic handled is mostly heavy coal tonnage, the average being from 15 to 20 trains eastbound per day. A certain amount of passenger and merchandise freight movement is assisted by the electric locomotives. Due to the nature of the traffic, all heavy freight trains being run as extras, the power house operation is irregular, the maximum load varying from 2,000 or 3,000 to 25,000 kw. in a short time. It may be noted that a standard freight train requires 12,000 hp. to accelerate on heavy grades.

The company's telephone and telegraph circuits are open wire along the company right-of-way and form a close parallel to the trolley and transmission circuits.

Under normal conditions, the inductive interference on telegraph circuits has been overcome to a very large extent by installation of 25-cycle, alternating current drainage shunts connected to telegraph relays. This in conjunction with the special booster transformer installation on traction circuits has cut down interference to a minimum.

In company telephone operation, the metallic telephone circuits pick up slight induction from harmonics in the 60-cycle signal transmission circuit, but no such trouble is experienced from the 25-cycle power used in traction. Under normal conditions, this induction is not severe and does not interfere with the operation of telephone

circuits. No special provisions are made to prevent interference other than special transposition.

In the case of signal operation it is difficult to separate normal conditions from abnormal conditions, but generally speaking, under normal conditions, very little trouble is experienced.

Even under abnormal conditions, such as flash-overs, or voltage surges, no cases are on record of telegraph protectors being burned out. In telephone circuits, an abnormal condition such as ground or flash-over on the trolley or transmission circuits usually causes a surge creating an induced voltage on telephone circuits sufficient to operate protectors. This surge may rise to a little over 200 volts as compared with a normal induced voltage of 70 or 80.

In signal operation under abnormal conditions, some of the signal appliances such as track relays, track transformers, fuse holders and reaction coils are burned up. Such cases are relatively infrequent.

No trouble of any sort has been experienced which can be attributed to electrolytic conditions.

As previously stated, inductive interference on through telegraph circuits has been overcome very largely by installation of 25-cycle, alternating current drainage shunts, consisting of retarding coils with condensers. Shunts have not as yet been installed in local stations on way wires.

The only direct protection on railroad telephone circuits is transposition.

As regards protection to signal apparatus, experiments are now being carried out with a section of electrification where the structures have been bonded to the running rails and this apparently gives protection to the signal apparatus; however, the experiments are not yet far enough advanced to make a definite decision. While it is believed the operation will be successful with clean ballast, it is somewhat doubtful whether the results will be as good with excessively dirty ballast, and it has not yet been settled whether the arrangement under trial gives complete broken rail protection.

The general scheme of protection against electrical interference is the installation of track or booster transformers, which are located on signal bridges, the purpose of these transformers being to prevent the current in the rail from flowing into the earth and causing disturbances on adjacent telephone and telegraph circuits.

As regards commercial concerns, the lines of the Bluefield Telephone Company approach within short distances of the track a various points.

Great Northern

The power required for the Great Northern Railway is developed at their hydro-electric plant located at Tumwater, Washington. The transmission lines extend from that point to a point a little west of Cascade Tunnel. This transmission line parallels the pole line which supports the telegraph and signal line circuits, generally at a distance of from 80 to 90 feet.

The transmission line consists of two parallel circuits, each having three conductors operating at 33,000 volts. The trolley is a three-phase system, using two trolley wires and the rail for the three conductors. The working potential is 6,600 volts, 25 cycles. Within the Cascade Tunnel the separation between transmission line and communicating circuits does not exceed 20 feet, and for some time after the installation of the transmission lines trouble was experienced from inductive interference on the telegraph circuits. When electric locomotives were first operated it was found that the interference was so great as to prevent the use of telegraph wires whenever a train moved through the tunnel. The trouble was remedied by installing a new twisted pair, steel armored, communication cable. After installing the new cable no further inductive interference was experienced. The cable removed was parallel laid and had no steel armor.

No inductive interference has been experienced with the electric train staff system installed in this territory.

Erie Railroad

Interference occurs in a section 19 miles north of a transformer station located at Avon, N. Y., and 15 miles south thereof. Specifically, between Rochester, N. Y., and Mt. Morris, N. Y., the railroad is paralleled for 14 miles north of Avon by a 60,000-volt, three-phase, 25-cycle transmission line, and the entire 34-mile section mentioned is equipped with a 11,000-volt, 25-cycle, single-phase distribution line (trolley wire). The telegraph pole line carrying four telegraph wires and one or two telephone circuits has a mean separation from the trolley wire of about 30 feet and from the transmission line of 60 or 70 feet.

Under normal conditions no appreciable disturbance arises from the transmission line, but induction from the 11,000-volt, single-phase line is heavy on all single telegraph wires which come into the section. Three of the wires running south from Rochester leave the electrified section at Avon, one going west 66 miles to Buffalo, and two going southeast 76 miles to Corning, N. Y. All of these carry the induced currents with slight diminution to their terminals. A fourth wire goes through both the section north of Avon and that south, unworkable at times, while a telegraph loop which exists in the southernmost six miles of the section south of Avon, or from Mt. Morris to Geneseo, is not affected. This loop works on a circuit which runs east and west of Mt. Morris on a foreign railroad.

Under abnormal conditions, such as short circuits and grounds, the troubles referred to above are accentuated.

No trouble has been experienced from electrolysis.

New York Central Railroad

On the West Shore branch of the New York Central line, for approximately 115 miles, a 60,000-volt, three-phase, 60-cycle, transmission line parallels the railroad communication circuits, generally on the opposite side of the track with an average separation of about 60 feet. There is no inducive interference under normal operations. Originally the transmission line was transposed throughout its length, but recently some of these transpositions have been removed without bad effect. Under abnormal conditions, due to grounds, broken wires, etc., severe surges are induced in railroad communication lines. Communication lines have standard transpositions.

On the Falls Road Branch a transmission line of 11,000-volt, three-phase, parallels the telegraph and telephone lines between Albion and Knowlesville, a distance of about 5.6 miles. The two lines are within conflict at certain points and trouble has only occurred due to contact.

On the Walkill Valley branch the railroad communica-

tion circuits are paralleled by a 22,000-volt transmission line for a distance of about 20 miles. The power line is on the same side of the railroad right-of-way as the telegraph and telephone lines for a distance of about 3½ miles. This circuit has interfered with normal operations due to irregular power circuit inducing hum on the dispatcher's circuit.

On the Phœnix branch, between Woodward and Phœnix, a three-wire transmission line parallels the railroad communication circuits and has been the source of considerable trouble in connection with the maintenance of the railroad communication circuits on account of high induced voltages.

In the electric zone of the Grand Central Terminal from New York to Harmon and from Mott Haven to North White Plains 11,000-volt, three-phase, 25-cycle, alternating current is transmitted to 9 substations; from Bronx Park to North White Plains and from Putnam Crossing to Ossining in aerial lines and the remainder of the transmission line in cables. The telephone and telegraph lines are in cables in the same sections where power line is cabled. In other sections the communication lines are part cable and part open wire on the opposite side of the track from the transmission line. There has been no electrical interference with communication or signal service.

The propulsion circuit, 660-volt D. C., is led through an under-running third rail. By the sectionalizing of the lead sheaths of communication cables the effect of electrolysis has been practically eliminated.

Chicago, Lake Shore & South Bend Railway

The Chicago, Lake Shore & South Bend Railway, an interurban passenger and freight electric railroad, extends from Kensington, Illinois, the junction with the Illinois Central Railroad, to South Bend, Indiana, a distance of approximately 75 miles. The main power plant is at Michigan City. From this point there is a 33,000-volt, single-phase, 25-cycle transmission line east to the substation at Terre Coupee. From Michigan City west there is a 33,000-volt, single-phase, 25-cycle line to the Calumet substation in East Chicago, and on the same pole line as far as the Calumet substation, a 33,000-volt, three-phase, 60-cycle line between the Michigan City power house and the Northern Indiana Gas & Electric Company's power house in East Chicago.

Trolley is energized at 6,600 volts, 25 cycles, single-phase, and is fed from the main power house and the two substations.

The railway company's communication and signal circuits are carried on the same pole line as the transmission circuits, and it is stated that no trouble on these communication and signal circuits has been experienced under normal conditions.

The Postal Telegraph & Cable Company's line parallels the Chicago, Lake Shore & South Bend Railway west of Michigan City between West Blair Farm and Baileytown, a distance of approximately 13½ miles with a separation of 90 feet to 375 feet, and between Dune Park and Aetna, a distance of approximately 6 miles with a separation of 75 feet to 600 feet.

Under normal conditions no serious interference is experienced on the Postal Telegraph duplexes.

Under abnormal conditions, however, due to short circuits and grounds, momentary troubles are experienced on telegraph circuits. It is stated that the greatest trouble is experienced when the Chicago, Lake Shore & South Bend cut out their 33,000 volt line and carry the whole load on the system from the 6,600 volt, single phase trolley. At such times serious trouble on the telegraph circuits is experienced. Nothing has been done by the Postal Telegraph Company which eliminates these conditions.

It is stated that no trouble has been experienced affecting the safety of employees or the public, nor has any trouble been experienced that could be traced to electrolytic conditions.

Conclusion

The Committee has not completed its examination of the subject and has in its files detailed data available for tabulation and proposes, after obtaining additional information from other sources, to prepare a statement showing comparative results, from which conclusions may be drawn.

Specifications for Material for Welding Mild Steel

THE following are specifications for welding material compiled for the railroads by the American Welding Society. These specifications deal only with material for welding mild steel. Others to be brought out later will deal with high carbon steel and with non-ferrous metals.

Electrodes, Iron and Steel (Bare)

1. *General:* The following specifications prefixed by the letter E are recommended for the purchase of all bare iron and steel electrodes for use in arc welding.

2. *Scope:* The electrodes herein specified are recommended as covering the usual railroad, shipyard and industrial requirements as are allowed by authoritative regulating bodies, such as the American Bureau of Shipping and the Interstate Commerce Commission, etc.

3. *Material:* Material made by the puddling process is not permitted.

4. *Physical Properties:* Electrodes shall be made of commercially straight wire of uniform homogeneous structure, free from irregularities in surface hardness, segregation, oxides, pipes, seams, etc. Diameter shall not vary more than plus or minus 3 per cent from diameter specified.

5. *Nomenclature:* The use of the prefix letter E is to indicate that the material is intended for electric welding.

6. *Chemical Composition* shall be within the following limits for mild steel.

MILD STEEL

No. E1A

Carbon	not over 0.06	of one per cent
Manganese	not over 0.15	of one per cent
Phosphorus	not over 0.04	of one per cent
Sulphur	not over 0.04	of one per cent
Silicon	not over 0.08	of one per cent

No. E1B

Carbon	0.13—0.18	of one per cent
Manganese	0.40—0.60	of one per cent
Phosphorus	not over 0.04	of one per cent
Sulphur	not over 0.04	of one per cent
Silicon	not over 0.06	of one per cent

7. *Recommended Sizes:* 3/32, ⅛, 5/32, 3/16 inch diameters.

8. *Uses:* For welding mild steel, structural shapes,

plate, bars or low carbon steel forgings and castings.

9. *Note:* Under the heading "Mild Steel" two analyses of material are specified, both of which are manufactured and acceptable.

10. *Surface Finish:* The surface shall be smooth and free from rust, oil or grease.

11. *Tests:* In the hands of an experienced welder electrodes shall demonstrate good weldability and shall pass through the arc in flat and overhead positions smoothly and evenly without detrimental phenomena.

12. *Packing:* Electrodes shall be delivered in coils or in straight 14-inch lengths, packed and wrapped as follows:

(a) *Bundles* of 50 lb. net weight, securely wired and wrapped in heavy weatherproof paper.
(b) *Bundles* of 50 lb. net weight, securely wrapped in heavy burlap.
(c) *Boxes* or kegs of 100, 200 or 300 lb. net weight and wrapped as per paragraph (a).
(d) *Boxes* or kegs of 100, 200 or 300 lb. net weight, and wrapped as per paragraph (b).
(e) *Coils* of approximately 50 or 100 lb. net weight, and wrapped as per paragraph (a) or (b).

13. *Marking:* All bundles, coils, boxes or kegs shall be provided with a metal tag wired or nailed on the outside bearing the following information:

Make.....
Specif. No.....
Dia.....
Nom. weight.....

14. *Ordering:* Material ordered under these specifications shall be known as:

"Electrodes, iron and steel bare American Welding Society Specifications No. 1, issued April 1, 1920."

All orders should be specified in pounds.

In addition, requisitions shall show the following:

Specif. No.
Size
Packing

As a guide in ordering, the following information is of use:

Size, inches	1/16	3/32	1/8	5/32	3/16	1/4
Lb. per 100 ft.	1.04	2.3	4.1	6.5	9.3	16.7
Feet per 100 lb.	9,615	4,273	2,403	1,537	1,067	600
Mils	63	94	125	156	188	250

Oxy-acetylene Welding Rods

1. *General:* The following specifications, prefixed by the letter G, are recommended for the purchase of all iron and steel welding rods for use in gas welding.

2. *Scope:* The welding rods herein specified are recommended as covering the usual railroad, shipyard and industrial requirements as are allowed by authoritative regulating bodies, such as the American Bureau of Shipping and the Interstate Commerce Commission, etc.

3. *Material:* Material made by the puddling process is not permitted.

4. *Physical Properties:* Welding rods shall be made of dead soft annealed commercially straight wire of uniform homogeneous structure, free from irregularities in surface hardness, segregation, oxides, pipes, seams, etc. Diameter shall not vary more than plus or minus 3 per cent from diameter specified.

5. *Nomenclature:* The use of the prefix letter G is to indicate that the material is intended for gas welding.

6. *Chemical Composition* shall be within the following limits for mild steel:

MILD STEEL
No. G1A

Carbon	not over 0.06 of one per cent
Manganese	not over 0.15 of one per cent
Phosphorus	not over 0.04 of one per cent
Sulphur	not over 0.04 of one per cent
Silicon	not over 0.08 of one per cent

7. *Recommended Sizes:* 1/16, 3/32, 1/8, 5/32, 3/16, 1/4, 5/16, 3/8 inch diameters.

8. *Uses:* For welding mild steel, structural shapes, plates, bars or low carbon steel forgings and castings.

9. *Surface Finish:* The surface shall be smooth and free from scale, rust, oil or grease, and may be plain or copper-coated.

10. *Tests:* In the hands of an experienced welder welding rods shall demonstrate good weldability and shall flow smoothly and evenly without detrimental phenomena.

11. *Packing:* Welding rods shall be delivered in coils or in straight 36-inch lengths, packed and wrapped as follows:

(a) *Bundles* of 50 lb. net weight, securely wired and wrapped in heavy weatherproof paper.
(b) *Bundles* of 50 lb. net weight, securely wrapped in heavy burlap.
(c) *Boxes* or kegs of 100, 200 or 300 lb. net weight and wrapped as per paragraph (a).
(d) *Boxes* or kegs of 100, 200 or 300 lb. net weight and wrapped as per paragraph (b).
(e) *Coils* of approximately 50 or 100 lb. net weight and wrapped as per paragraph (a) or (b).

12. *Marking:* All bundles, coils, boxes or kegs shall be provided with a metal tag wired or nailed on the outside, bearing the following information:

Make.....
Specif. No.....
Dia.....
Nom. weight.....

13. *Ordering:* Material ordered under these specifications shall be known as:

"Oxy-acetylene welding rods, American Welding Society Specifications No. 1, issued April 1, 1920."

All orders should be specified in pounds. In addition, requisitions shall show the following:

Specif. No.
Size
Packing

As a guide in ordering, the following information is of use:

Size, inches	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
Lb. per 100 ft.	1.04	2.3	4.1	6.5	9.3	16.7	2.6	37.5
Feet per 100 lb.	9,615	4,273	2,403	1,537	1,067	600	383	266
Mils	63	94	125	156	188	250	312	375

Electrification of South African Railways*

THE South African Government Railways are about to begin the electrification of two sections of the system, and tenders are now being invited for power house equipment and rolling stock. The lines to be electrified immediately are the Cape Town-Simonstown Suburban line, 22 miles long, and the Durban-Pietermaritzburg section of the Natal main line, 70 miles long.

The Simonstown line is partly double and partly single track. It carries a large and rapidly growing passenger traffic. Exclusive of season and "trip-bearer" ticket holders, the number of passengers carried rose from 2,701,105 in 1911 to 5,080,284 in 1919-1920. In the latter year 151,520 season tickets were issued, the increase over 1914 being more than 60,000. Electrification of this branch has been decided upon entirely on account of the heavy passenger traffic, and the undertaking presents no features of special interest. Multiple unit trains will be used.

The Natal Section

The Durban-Pietermaritzburg section of the Natal main line differs completely from the Simonstown line. The Natal railway has always afforded plenty of scope for the ingenuity of the engineer. As originally located, it included a large number of gradients as steep as 3.3 per cent and curves of 20 deg. radius were equally numerous. The line crosses a succession of spurs of the Drakensberg range, divided by deeply cut river valleys, so that it resembles a switchback on an enormous scale. In the distance of rather over 70 miles from Durban to Pietermaritzburg, a summit of 3,000 ft. is reached near Thornville Junction, and the line then descends to about 2,250 ft. at Pietermaritzburg, where it again starts to climb steeply with occasional intermediate descents to over 5,000 ft. near Highlands. It then falls 1,500 ft. as it crosses the Tugela Valley, and then mounts to about 5,500 ft., at which altitude it crosses the Drakensberg and enters the Transvaal. An up train ascends about 12,000 ft. in the 300 miles between the coast and the Transvaal border.

Tracks Badly Damaged by Steam Locomotives

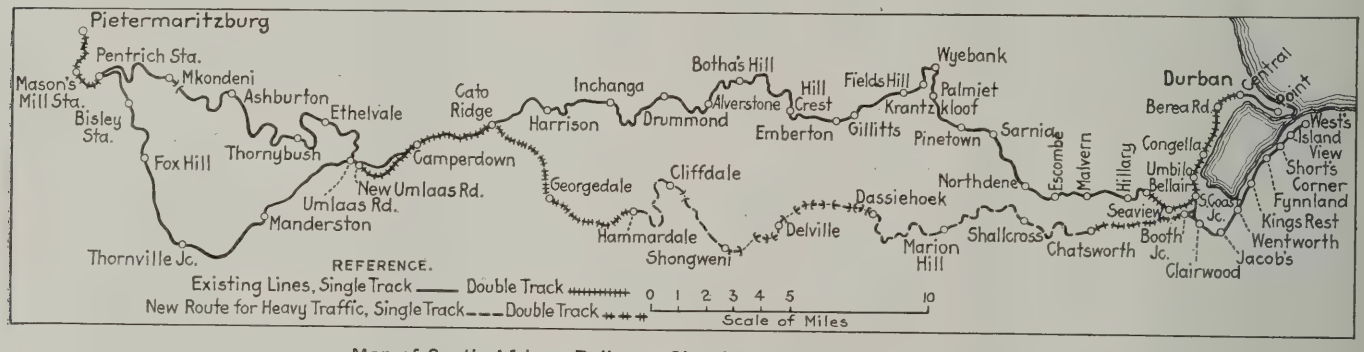
It may be readily imagined that under these conditions there has been a serious limitation on trainloads and speeds, while operating costs have been very high. About the time of the South African War, a decapod side-tank locomotive, with only the six center driving wheels flanged, was introduced with the object of increasing the load hauled by a single engine unit. Though locomotives of this type possessed high tractive power, they did an extraordinary amount of damage to the track, in spite of the fact that 80 lb. rails seated on heavy iron chairs were in use. The cast iron chairs were broken by scores on each trip, and it was found necessary eventually to convert these engines to eight-coupled. Only about a dozen are still in use in their original form.

Extensive Deviations Have Been Built

Even before the Natal Government Railways ceased to have an independent existence a certain amount of work had been done in the direction of deviating the main line in order to secure a maximum gradient of 1 in 50 and curves of not less than 500 ft. radius. Since the Union came into existence in 1910 very extensive works of this nature have been carried out, and maximum gradients of 1 in 60 and even 1 in 70 are now sought wherever possible. Usually, this involves a lengthening of the line. Owing to the rapid rise and fall of the country, tunnels, unless of prohibitive length, would not help much, and the only means of flattening gradients is by adopting an even more meandering alinement than the extremely sinuous location of the original line. The result is that the traverse of the line is a succession of what in local parlance are called "doglegs."

In several cases an entirely new line has been built, as between Pietermaritzburg and Cedara, and also between Pentrich and Camperdown. Fast passenger and heavy freight traffic are routed over these new lines and local trains continue to use the old track. The most ambitious of these deviations—which can more properly be described as an entirely new railway, in places five miles distant from the old line—is now nearing completion. As the accompanying diagram shows, the new line, which is just over 40 miles long, leaves the South Coast branch of the Natal system at Booth Junction and runs thence roughly parallel to the original route, which it rejoins at Cato Ridge.

The new line has ten tunnels, of which the longest—known as the Delville tunnel—is 1,001 yards from portal to portal. At the Cato Ridge end 8½ miles of deviation to Hammardale will be double-tracked. Wherever the new and old lines run on the same alinement duplication has been carried out, so that when the new route is opened there will be two tracks throughout between Durban and Pietermaritzburg, though they will run alongside one another only for a small fraction of the



Map of South African Railways Showing Sections To Be Electrified

*London Times Engineering Supplement, March, 1921.

distance. Between Durban and Bellair the old line is double. From Durban to South Coast Junction, where the two routes really diverge, the track will probably be quadrupled in the near future. In the section from South Coast Junction to Booth Junction, where the new line parts company with the South Coast branch, and for an additional 3½ miles beyond Booth Junction, the track will be double. For the remainder of the route to Hammardale the new line is single track throughout. Between Bellair and Cato Ridge the old line will also remain single. Thence to New Umlaas Road both lines follow the same alinement as an ordinary double-track railway, but from a point near Camperdown to the old Umlaas Road Station the old line will remain at a different level. There the two diverge widely, the old line running via Thornville Junction, where the Richmond branch is joined, to Pentrich, while the new line follows a more direct but sufficiently sinuous route to the same station. From Pentrich to Pietermaritzburg the two again combine to form a normal double-track line. This is, however, considerably removed from the original and now abandoned location between these two stations.

The Two Routes

As soon as the Booth Junction-Cato Ridge line is opened it will be used for fast passenger and through freight trains. Local trains will continue to run over the original line, along which such population as there is is clustered.

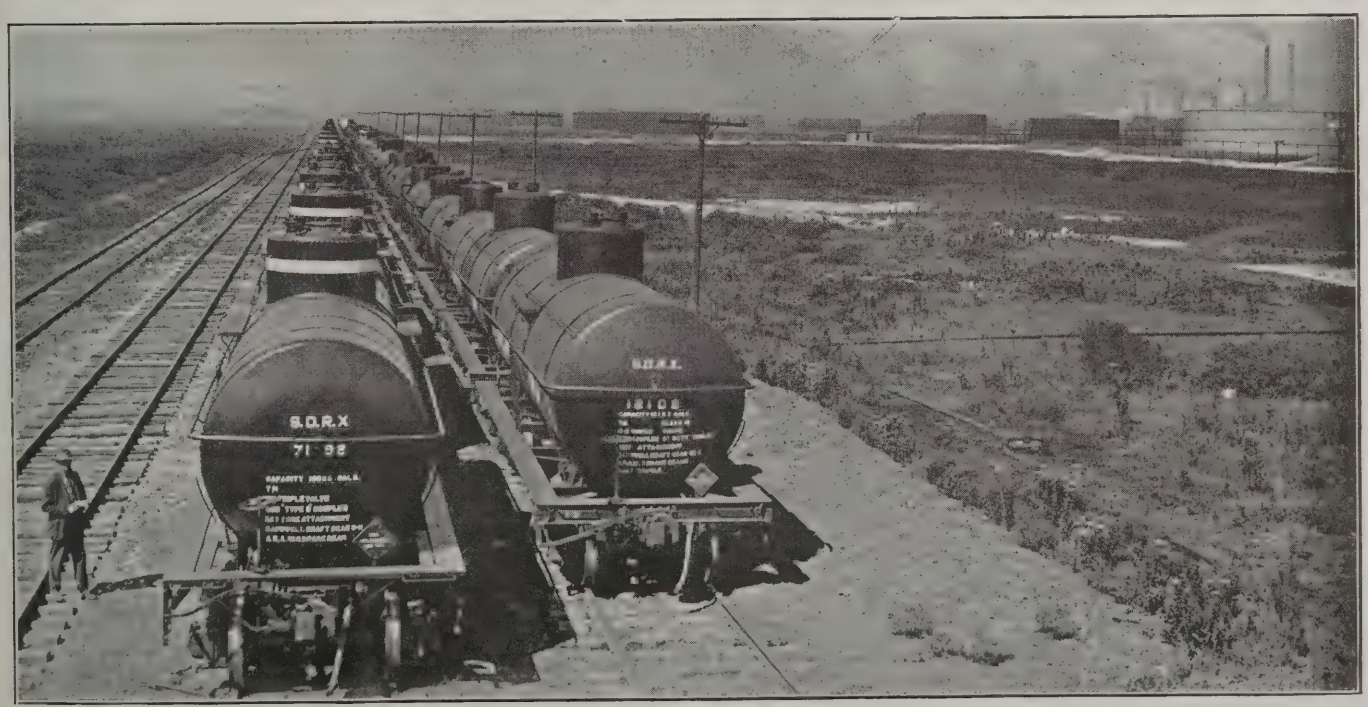
Both the old and the new lines are to be electrified as well as the local lines from Durban to the Point and from Clairwood to Wests, which carry heavy freight and coal traffic to and from the wharves on both sides of the harbor. The Wests line will probably be doubled.

On the Natal line heavy electric locomotives will be employed. The standard freight engines will be about 120 tons in weight, capable of hauling a 1,200-ton train on the level at about 40 miles an hour, or a 1,800-ton train at about 30 miles. Such locomotives will have a capacity of about 2,800 hp., compared with 1,000 to 1,400 hp. in the case of the steam locomotives now in use. For passenger trains a type of locomotive with a weight on driving wheels of about 72 tons and a tractive effort of about 30,000 lb. is specified. The express passenger engines have been designed by the consulting engineers, Messrs. Merz and McLellan, for a normal speed of 55 miles on the level and 28 miles on ruling gradients when hauling a train of 15 standard main line coaches.

The fastest train running between Durban and Pietermaritzburg at present takes nearly four hours to cover the distance—about 72 miles. There will not be much level track, even on the new line, but, assuming an average speed of 36 miles for the electric trains, it will be possible to halve the present timing. It will be recalled that the system to be adopted is 3,000 volts direct current, with overhead transmission. In some respects the Natal electrification will more closely resemble the Chicago, Milwaukee & Puget Sound line than any other undertaking, though the South African work can be fairly regarded as distinctly of its own kind.

Illinois Electric Railways

Illinois is served by 90 electric railway companies, which have 3,841 miles of track, which, if stretched out in a straight line, would reach from New York to San Francisco and then out into the Pacific Ocean 655 miles. These lines carry more than two billions of passengers annually, and represent an investment of $456,200,000 made by thrifty men and women in providing the State with service.



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A Scene at East Chicago

Electric Lighting of Steam Railway Coaches*

A Discussion of Illuminating Units and Their Application to the Various Classes of Railway Service

RAILWAY car lighting differs from other classes of lighting both in the methods of obtaining the energy for lighting and in the application of the lighting units.

The fact that a car is continually on the move makes it necessary to obtain the energy from a stored supply, or to generate it on the car itself. This means that the supply is limited, and that it must be utilized in the most efficient manner possible.

The lighting fixtures must be permanently secured in position, and out of the way of seats, baggage racks and sleeping car berths, which limits their application to the ceiling of the car. This gives no flexibility to placing of the units to get the desired effect.

Much careful study has been given the matter, however, and the results obtained as exemplified by the best present practice are very satisfactory.

A series of tests extending over several weeks was made in 1912 by representatives of the Post Office department, several of the railroads, and interested manufacturers on different methods of lighting postal cars. A few years later a similar series of tests were made under the direction of the Association of Railway Electrical Engineers, on methods of coach lighting, and it is mainly on the data obtained by these tests that the illumination values given later are based.

Electric Lighting Systems

What is known as the "Axle Generator System" has come to be almost exclusively used for lighting cars by electricity. The use of the straight storage system, by which the current was obtained from storage batteries which were charged while the car was at a terminal, has almost entirely disappeared, owing to the fact that cars were kept too long out of service for charging and were dependent on a stationary plant. A few cars are still lighted by the "Head End System," in which the current is obtained from a steam driven generator set in the baggage car of the train, but owing to its lack of flexibility this system has had a limited application.

In the axle generator system the current is generated by a dynamo driven from the axle of the car. This dynamo provides current for the lights, and charges a storage battery which provides light when the car is not in motion. With this system, the car provides its own power plant, and has an ample supply of current, whenever it may be in service. Such attention as is necessary is easily given during its regular lay-over periods.

The essentials of such a system are as follows:

A generator mounted on either the car body or the truck with some form of driving system between the car axle and the generator.

A storage battery to furnish current when the car speed is not sufficient to drive the generator at a speed to give the proper voltage.

A regulator to govern the output of the generator at varying speeds, and to properly charge the storage battery and protect it from overcharge.

A regulator to maintain proper voltage at the lamps.

Some means of keeping the polarity of the generator constant when the direction of movement of the car changes.

These conditions have been successfully met in various ways. The majority of equipments in use have the following features:

The generator is mounted on the car underframe and is driven by a belt. The generator is controlled for output at varying speeds by carbon pile rheostat in its field circuit which gives a constant current output until the battery approaches full charge, when the battery is protected from overcharge by the control passing to voltage, or by having the charge discontinued by a meter which measures the ampere hours supplied to the battery. The lamp voltage is held constant by an automatic carbon pile rheostat.

At present there is some demand for a more positive drive than the belt, which does not always give perfect service, especially in bad winter weather. Various types of gear or other positive drive are being investigated but it is doubtful, that when all the conditions of application to the car, first cost, and cost of maintenance, are considered whether the increase in service will be justified.

Coach Illumination

Coaches are of course important as they constitute the majority of cars in use and carry more people than any other class of car.

A certain amount of general illumination is necessary, but the principal illumination is required for reading, and the lighting system should be designed for proper illumination on a plane 45 deg. to the horizontal, and at right angles to the center line of the car.

The lamp fixtures may be either mounted on the center line of the car on the upper deck or there may be a row on each side of the car directly over the seats mounted on the lower edge of the side deck.

The spacing most used for the lamps is six feet, the mounting height for center lamps is about eight feet, and for side lamps, about six feet six inches.

Up to the present the open mouth type of reflector, of either heavy density opal glass or clear prismatic, has been employed for coach lighting.

The use of these types of reflectors with six foot spacing and 50 watt type B train lighting lamps giving 506 lumens or 84 lumens per running foot of car length will give about the following illumination results:

	FOOT CANDLES				
	45 Degree Plane		Horizontal Plane		Efficiency, Horizontal
	Window Seats	Aisle Seats	Mean	Average	Plane
Heavy density opal.	2.60	3.51	3.06	4.48	49.7
Clear prismatic.....	2.55	3.54	2.95	4.23	46.6

The type C lamp has also been made available for car lighting purposes. While the intensity of illumina-

*Abstract of a paper by Geo. E. Hulse, Ch. Engr., Safety Car Heating & Lighting Co., read before the New York Section of the Illuminating Engineering Society, March 10, 1921.

tion can be increased by the use of these lamps, the wisdom of their use in open mouth reflectors is questioned as under these conditions it is almost impossible to get away from the effect of the high intensity filament. Even though the filament is properly screened there are bright spots on the reflector which cause eye fatigue.

Totally enclosing units placed close to the ceiling are however being introduced for coach lighting, and these give satisfactory results as to illumination and present a pleasing appearance.

With the better grade of glass available at present the illumination values obtained with the 50 watt type C lamps (740 lumens) giving 123 lumens per running foot of car length would be about as follows:

FOOT CANDLES

45 Degree Plane		Horizontal Plane		Efficiency, Horizontal Plane
Window Seats	Aisle Seats	Mean	Average	22 0/0
2.18	2.40	2.29	2.82	

Using the 75 watt type C lamp (1024 lumens) or 120 lumens per running foot of car these values would be as follows:

FOOT CANDLES

45 Degree		Horizontal Plane		Efficiency, Horizontal Plane
Window Seats	Aisle Seats	Mean	Average	22 0/0
3.02	3.32	3.17	3.92	

It will be noted that by using the same wattage, the values obtained with the type C lamp and enclosing bowls are about 23 per cent lower than those with open mouth reflectors and type B lamps. To get equal illumination it is necessary to increase the wattage 50 per cent with the enclosing bowl type. In the latter case however the illumination is of a better character and the appearance of the car is considerably improved.

Dining Cars

Most of the novelties in car lighting are used in the dining cars. The table and its furnishing are the most important item in the car and the high illumination must be concentrated on each table. General illumination of fairly high intensity has always been found necessary so that the car would present a cheerful appearance to the person entering it. Installations with a high intensity on the tables and a low general illumination have not been found satisfactory. Generally illumination can be obtained from fixtures mounted on the center deck, either direct or semi-direct. For table illumination fixtures should be mounted over each table and no more satisfactory type of unit has been developed than that which uses the concentrated reflector with a redirecting plate under it to give the proper distribution for maximum light on the table top.

For general illumination a semi-direct fixture is now generally preferred and sufficient illumination is obtained with such fixtures mounted six feet apart using a 50 watt type C lamp.

The illumination on the table top should be from five to seven foot candles and this can be obtained by the use of a 50 watt type C lamp in the table fixture mentioned.

Sleeping Cars

Sleeping cars require lighting for general illumination, for reading or working at the tables in the sections, and for illumination of the berths after they are made up.

General illumination is obtained by center lamps placed close to the ceiling to prevent interference of the fixture with the upper berth. Small units placed in the corner of each section provide additional local illumination for reading and to light the made-up berths.

The staterooms of a sleeping car and a compartment car are lighted in the same way.

Smoking rooms have a center lamp for general illumination and bracket lamps back of the fixed seats to afford proper lighting for reading.

The passageways are lighted by ceiling fixtures using either an open-mouth reflector or a fixture with reflector and directing plate set flush with the ceiling.

For lighting the berth section of the car after the berths are all made up a fixture has recently been developed which is secured to the seat frame and throws the light on the floor so that it is easy to find the way along the aisle after all the ceiling lights have been extinguished in this section.

The present practice is to use total enclosing center lamps having a hemispherical bowl placed against the ceiling. Type C 100 watt (1461 lumen) lamps are used, and the illumination on the reading plane probably averages 4.5 foot-candles.

Parlor Smoking Cars

This type of car presents a rather difficult problem, as the seats are arranged so that the occupant faces the center of the car. Best results are obtained by the use of a few center lamps for general illumination, and bracket lamps placed on the side of the car back of the chairs for reading light. Cars having a flat side deck can be fitted with reflecting units directly over the chairs instead of bracket lamps.

Parlor Cars

The conditions in this class of car are very similar to those in the passenger coach, and the same type of installation is used, although indirect lighting can be better used in parlor cars owing to the fact that the walls and ceilings can be maintained in better reflecting condition.

Postal Cars

Postal cars require greater illumination than those of any other class, as the work done demands constant and arduous use of the mail clerk's eyes. A very thorough investigation was conducted some years ago by one of the large railroads assisted by various manufacturers and participated in by the Standard Car Committee of the Post Office Department. Various types of installation were tested, and determinations were made of the amount of light necessary for the postal clerk's work. From the results obtains by these tests the committee issued specifications for lighting which must be met in every postal car.

Postal cars are generally divided into three sections; the letter distributing cases, the bag distributing racks, and the storage space. The distributing cases require high illumination on the vertical plane of the box labels and on a horizontal plane for reading the addresses on the mail. The bag distributing racks require high il-

INITIAL VALUES OF ILLUMINATION REQUIRED

	Foot-Candles	
	Minimum	Maximum
Bag rack portion, center of car—horizontal	3.75	12.00
Mouth of bags, measured 18 in. from side of car—horizontal	2.00	12.00
	3.75	19.00
Letter cases	3.75	19.00
Over table—horizontal	1.66	19.00
Face of case—vertical	2.00	12.00
Storage portion		

lumination on the horizontal plane for the labels on the bag racks. The storage end requires a fair general illumination.

These initial values are set to give proper illumination with a 40 per cent depreciation in the efficiency of the installation.

These specifications in the 60 ft. car are easily fulfilled by the use of fifteen 50 watt (506 lumen) lamps. Some installations are being now made with the type C lamp in postal cars but enough experience has not been had with this installation to determine as to whether it is entirely satisfactory.

Private Cars

A private car is a combination of several types of cars and the lighting is accomplished in the different sections somewhat as it is in the class of a car to which that section corresponds. The observation room resembles somewhat the parlor smoker, and in this part of the car general illumination is obtained by center lighting, with bracket lamps behind the chairs, or half deck units for local lighting. In private cars, however, more latitude is allowed in fixture design, and frequently the center lighting is obtained from one large fixture placed in the ceiling of the observation room.

Local lighting is provided for the gauges and speed indicating devices with which most business and private cars are equipped, so that these instruments may be read when the other lamps in the car are extinguished to allow track inspection from this part of the car at night.

All cars having vestibules have lamps over each set of steps directing light on the steps. A flush type metal reflector is generally used.

Baggage Cars

Baggage cars do not require a high intensity of illumination but the distribution must be such that a moderate illumination is obtained both on the horizontal and vertical planes, and this illumination on the vertical plane must be of a fair value up to within about two feet of the car roof. The reason for this is that the lading car is sometimes piled high, and there must be sufficient light to read labels or marking on the packages. Glass reflectors are also not desirable on account of breakage. The present preferred practice is the use of an enameled reflector of the R. L. M. type placed as close to the ceiling as possible. These fixtures are spaced about ten feet apart, and 50 watt (740 lumen) type C lamps are used. This installation will give an illumination of about 4.5 foot candles average on the horizontal plane, and values ranging from 1 to 5 foot candles at different heights in the vertical plane. Baggage cars are also provided with a fixture over each door designed to light the doorway and a baggage truck placed for loading the car.

Reflectors and Glassware

A number of types of reflectors and enclosing units have been developed for car lighting uses. For coach lighting, and other classes of cars where efficiency is the prime object, and appearance a secondary consideration, the open-mouth reflector is in almost universal use. Best results are obtained with a reflector giving the maximum candle-power at 45 degrees.

The following are the principal types of this class of reflector, together with the illumination obtained and the efficiency using a 6 ft. spacing, giving 84 generated lumens per running foot of the car:

	Average illumination on 45 degree reading planes, foot-candles			Illumination efficiency on 45 degree plane
	Aisle seats	Window seats	Average	
Prismatic clear	3.34	2.72	3.04	34.2
Heavy density opal	3.03	2.35	2.69	30.2
Medium density opal	2.52	2.07	2.30	25.9
Prismatic satin finish	2.44	1.89	2.17	24.3
Light density opal	2.25	1.91	2.08	23.5

Where appearance is the primary consideration enclosing units are used, and the energy efficiency somewhat sacrificed.

The following results are obtained with this class of unit using 123 lumens per running foot of car length:

	Average illumination on 45 degree reading planes, foot-candles			Illumination efficiency on 45 degree plane
Enclosing units	Aisle seats	Window seats	Average	
Light density opal	2.00	1.78	1.90	14.6
Shallow prismatic reflector with light density bowl	2.55	2.00	2.27	17.5
Reflecting and diffusing globes	2.64	2.27	2.46	19.0
Semi-indirect	2.86	2.27	2.57	19.8
Total indirect	2.50	2.03	2.26	17.4
Bare lamp	2.15	2.07	2.11	16.3

All of the foregoing are for electric light.

Fixtures

Lighting fixtures for use in railroad cars require special design and construction, and embody some features not found in fixtures built for other purposes.

1. They must be substantial to withstand the constant vibration to which they are subjected.

2. They must be easily removable for refinishing when the car goes through its regular shopping.

3. The arrangements for holding the glassware must be such that it can be easily applied, or removed for cleaning, but at the same time must be securely held so that there is no danger of its jarring loose.

4. They must be of suitable color and design to harmonize with the interior treatment of the car.

5. The mechanical design must be simple and all working parts must be easily accessible.

The first condition is met by careful mechanical design, suggested by experience in this class of work, as fixtures built for other uses are wholly unfit for use in railway cars.

The second feature is generally covered by a type of construction in which a plate or a spider is firmly fastened to the car ceiling, this plate forming the support for the socket. The ornamental part of the fixture is secured to this plate, but may be removed without disturbing in any way the electric connections or the attachment to the ceiling.

It has been found that no change in design of fixtures is necessary to accommodate the type C lamp as most of the fixtures are designed with sufficient radiant capacity to accommodate the type C lamp properly.

The Association of Railway Electrical Engineers have recently adopted four standard lamp positions. These are the 1½ in., 1 in., ½ in. and zero, these dimensions indicating the distance between the top of the contact point of the lamp and the top of the reflector.

The question of suitable design is one which is governed to a certain extent by the wishes of the purchaser, but I believe that the results obtained in car lighting work compare very favorably with that in other lines.

THE INTERCHANGE

Transforming a Transformer

Transformers constructed for one purpose can frequently be successfully changed to operate in connection with quite another set of voltages. The sketch shown in Fig. 1 illustrates a small transformer used to step down energy from 55 volts to 10 and 12 volts. Being of only

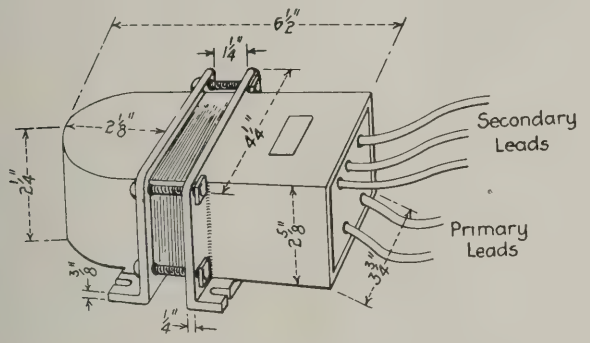
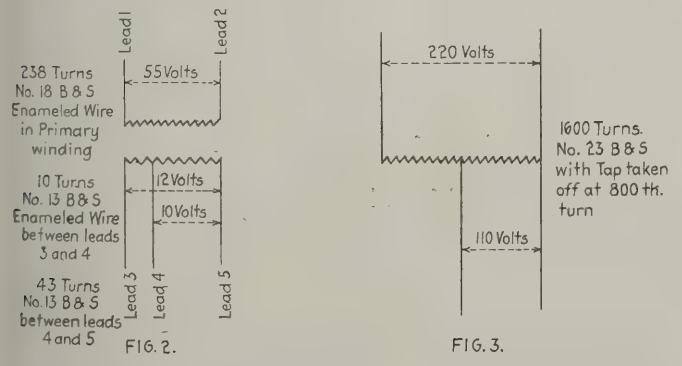


Fig. 1—Type of Transformer Used

50 watt capacity no other means for cooling is needed than contact with air. However, when this transformer was taken apart for the purpose of reconstructing it as a step-up transformer to boost voltage from 110 volts to 220 volts, a number of complications arose, chief among which was the excessive heating which developed in the


Lead 1
Lead 2
238 Turns No. 18 B & S Enameled Wire in Primary winding
55 Volts
10 Turns No. 13 B & S Enameled Wire between leads 3 and 4
12 Volts
10 Volts
43 Turns No. 13 B & S between leads 4 and 5
Lead 3
Lead 4
Lead 5
FIG. 2.
220 Volts
1600 Turns. No. 23 B & S with Tap taken off at 800 th. turn
110 Volts
FIG. 3.

Figs. 2 and 3—Welding Data and Diagrams

core. It was hoped to retain about the same watt capacity when used as a step-up transformer. A number of attempts were made at winding the core with individual primary and secondary circuits, but these methods were necessarily discarded for the reason that the winding space available was not sufficient to accommodate the required amount of wire. The double wiring was, therefore, abandoned in favor of a single winding of the auto-transformer type.

The windings on the original transformer were as indicated in Fig. 2, there being 238 turns of No. 18 B & S wire used on the 55-volt or primary winding, and 53 turns of No. 13 B & S wire on the secondary, a tap being taken off ten turns from one end. Considerable difficulty was experienced in estimating correctly what the winding conditions should be for the changed transformer, but after more or less cutting and trying a single winding of 1,600 turns of No. 23 B & S wire was applied and found to be satisfactory. The core thus wound formed an auto-transformer, a tap being taken off at the 800th turn. The diagram in Fig. 3 shows the conditions in the changed transformer. Fig. 4 shows the shape of the laminations in use. It was first found that

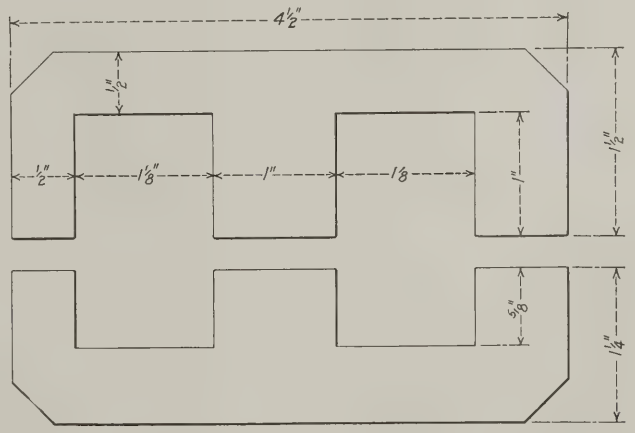


Fig. 4—Dimensional Sketch Showing Shape of Laminations Used

the core grew very hot when used in stepping up voltage from 110 volts to 220 volts. Further experimenting developed the fact that by reducing the laminations to practically one-half of the original number, the heating was greatly reduced, and finally when the amount of iron was further reduced by cutting away one-half of the case projecting to the right from the laminations, Fig. 1, the heating was eliminated altogether.

The resulting transformer did not quite accomplish the 110-220-volt transformation, but the actual figures obtained, 110-217 volts, were sufficiently close for practical purposes and did not justify the rewinding of the core to gain the additional 3 volts.

It is evident from the experience gained in the foregoing work, that a transformer can be wound for voltages quite different from those for which they were orig-

inally constructed, but it is also evident the procedure must involve more or less cut and try methods as the variables involved in small transformers are not open to simple mathematical calculations.

Handy Table for Drill Press Operators

By M. F. Hand, Electrical Foreman
A. T. & S. F. Ry. Co., Topeka, Kansas

In most small shops, where general repairs of various kinds are made, and especially where only a dozen or so workmen are employed, the several machines are run usually by "most anyone" who can handle them under the foreman's supervision.

This is especially true in the case of the drill presses and I have found that a table mounted near the presses, showing the sizes of drills to be used for the various classes of work is very convenient and efficient, saving considerable time, especially on a "hurry up" job.

This table is stenciled on a sheet of polished brass and shows the size of drill to be used for holes to be tapped out as well as to fit the body of standard machine screws, machine bolts or pipe and conduit. The table also shows the number of threads per inch of the various sized screws, bolts, etc.

In this connection, we have also mounted a rack holding the smaller drills from 1/16 in. to ½ in., while the larger drills are conveniently arranged on shelves near the press. The rack is made of a piece of hard wood ⅞ in. thick, 2 in. wide and long enough to accommodate all the straight shank drills ordinarily used, each hole being drilled into the edge of the wood 1/32 in. larger than the drill it is to contain. On the face of the rack is secured a strip of metal, upon which the sizes of the drills are stenciled in the same order as they appear on the rack.

To overcome the liability of the workman to place the drill in the wrong hole, after using it, and to serve as a check where particular work is to be done, a gage made of 3/16 in. x 1 in. O. H. steel has been secured to the wall just above the rack. Through this gage holes have been drilled for each sized drill the rack contains. Each hole is drilled with a new drill, and stenciled according to its size, so that the workman may readily select the drill he desires, and know he has the proper size for the work he has in hand. If desired, the gage may be case-hardened, thus insuring its reliability and maintaining its accuracy.

U. S. STANDARD SIZES OF BOLT, MACHINE SCREW AND PIPE THREADS

Machine bolts

Diam of bolt, in.	Threads per in.	Drill for tap, in.	Distance between flats of nuts, in.
¼	20	7/32	½
5/16	18	¼	17/32
⅜	16	5/16	19/32
7/16	14	3/8	11/16
½	13	7/16	⅞
9/16	12	31/64	31/32
⅝	11	17/32	1⅛
¾	10	21/32	1¼
⅞	9	¾	1 7/16
1	8	⅞	1⅝
1⅛	7	31/32	1 13/16
1¼	7	1 7/32	2
1⅜	6	1 7/32	2 3/16
1½	6	1 11/32	2 3/8
1⅝	5½	1 7/16	2 9/16
1¾	5	1 17/32	2¾
2	4½	1 25/32	3⅛
2¼	4½	2 1/32	3½
2½	4	2¼	3⅞

Machine screws

No. of screw	Threads per in.	Drill for tap, in.	Drill for body, in.
4	36	3/32	1/8
6	32	7/64	9/64
8	32	9/64	11/64
10	24	5/32	13/64
12	24	11/64	15/64
14	20	3/16	¼

Pipe and conduit

Size of pipe, in.	Threads per in.	Drill for tap, in.	Drill for body, in.
⅛	27	11/32	7/16
¼	18	29/64	9/16
⅜	18	19/32	11/16
½	14	23/32	⅞
¾	14	15/16	1 1/16
1	11½	1 3/16	1 5/16
1¼	11½	1 35/64	1¾
1½	11½	1 51/64	2
2	11½	2 3/16	2 3/8
2½	8	2 11/16	2⅞

A Strange Case of Motor Trouble

Early one morning a few days ago I received a "hurry-up call" from one of the shops, the foreman informing me, over the 'phone, that the starting box smoked. Arriving at the scene of the trouble I found that the starting box in question operated a motor some twenty-five or thirty feet above the floor. On moving the starting box handle over a couple of notches the motor refused to start, but something squeaked slightly. As the natural inference is an open field circuit when a motor refuses to start if its armature circuit is intact, I removed the field lead at the starting box and moved the handle to the first notch. I touched the field lead on the field terminal and drew an arc, thus showing the field circuit to be closed. Therefore, I decided to investigate the motor and procured a ladder. On mounting the ladder I found some rags and a rat's tail with Mr. Rat attached—caught between the armature and the pole piece. As Mr. Rat was still very much alive it was necessary to do away with him before extricating his tail. When the motor was stopped the previous evening he had dragged the rags into the nice warm motor to make himself a bed and was just unlucky enough to be caught when it was attempted to start the motor the next morning.

Telepathy Works on Wrong Line

"Hello, Jack, I was just thinking of you," called the clerk as his friend, whom he had not seen in weeks, entered the office. "That shows what psychology can do.

"You know I have long been a student and exponent of the power of the mind over matter, and you have proved to-day that I am right. Mind does triumph over matter."

"How have I proven it?"

"By coming in here just now," exulted the student-clerk, laughing. "I have been concentrating on you all morning and ordering you by telepathic wave lengths to come in here to see me. I have a date for to-night and I want you to go with me."

"Wait a minute, you got me all wrong," corrected the visitor. "I didn't come in here in answer to your wave lines. I came to collect that $5 you owe me."—*N. Y. Sun.*

Did It Ever Happen to You?

A pretty girl sat in a railroad train,
As lonesome as she could be;
And she said to herself, with a little sigh,
"If he'd only talk to me."

The young man sat just across the aisle
From the girl with the pretty stare,
And he said to himself, "If I sit with her,
I wonder if she would care?"

And so they rode the whole long day,
And neither one of them knew
Just what the other was thinking of—
Did it ever happen to you?"

—*Penn State Froth.*

Steps to Success

Be Agreeable.
Know Your Job.
Don't Argue.
Make Things Plain.
Tell the Truth.
Be Dependable.
Remember Names and Faces.
Don't Be Egotistical.
Think Success.
Be Human.

—*Barker News.*

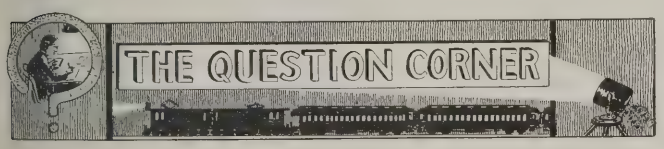
A Real Man

The test of a man is the fight he makes,
The grit that he daily shows,
The way he stands on his feet and takes
Fate's numerous bumps and blows.
A coward can smile when there's naught to fear,
When nothing his progress bars,
But it takes a man to stand up and cheer
While some other fellow stars.

—*Chords.*

Ten Rules For Efficiency

Be inspired by and work for love of work.
Anticipate requirements and develop resources.
Know both sides of the question and eliminate errors.
Master circumstances, recognizing no impediments.
Be courteous ever, permitting reason to modify rule.
Do the right thing, in the right way, at the right time.
Do things better than they were ever done before.
Know what is to occur, whether it occurs or not.
Be a confirmed optimist; don't worry about what happens, but see that it doesn't—to your people.—*Exchange.*



Answer to Last Month's Question

If each edge of a wire cube has a resistance of one ohm what will be the resistance between two diagonally opposite corners of the cube?

Let us first analyze the diagram in Fig. 1. It consists of a wire cube each edge of which has a resistance of one ohm. It is fairly obvious that the joint resistance from *O* to *P* must be something less than one ohm, for plainly there are a number of paths which the current may take from the point *O* to the point *P*. Three of the lines, *A, B* and *C*, radiating from *O* are shown heavier than the others and in a similar manner three other lines, *X, Y* and *Z*, radiating from *P* are indicated by dotted lines. Between these six lines mentioned it will be seen that there are six other lines numbered 1, 2, 3, 4, 5 and 6. These numbered lines serve as connections between the first set of lines *A, B* and *C*, and the second set *X, Y* and Z. Furthermore, the connections between *A, B, C* and *X, Y,* Z are symmetrical so that if the cubical wire frame actually formed a part of an electric circuit, the current which would flow out at the point *O* would be exactly the same in each of the three branches *A, B* and *C*. Since each of these lines has a resistance of one ohm and the same current flows in each, it follows that the potentials at the ends of *A, B* and *C* will be exactly the same. This being true, it would be perfectly possible to join the ends of *A, B* and *C* together without affecting the electrical condition of the circuit in any way. The same may be said of the lines *X, Y* and Z for the potentials existing at the ends of these lines will likewise be identical. If the ends of

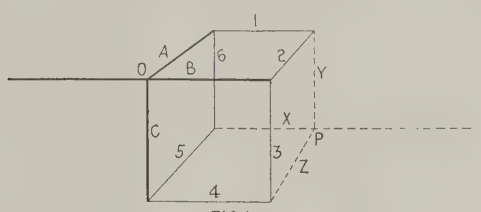


FIG. 1.

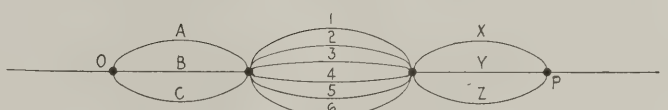


FIG. 2.

Diagram Showing How Cubical Wire Frame Can Be Simplified

X, Y and Z were joined together as would be quite permissible, we should find that all of the numbered lines 1, 2, 3, 4, 5 and 6 were in reality six parallel lines of one ohm, each connecting the points of common potential at the ends of *A, B* and *C* with corresponding points of potential, but of lower value, at *X, Y* and Z. Our cubical diagram could therefore be represented by Fig. 2, which immediately simplifies the whole problem. It is plain enough from this figure that the joint resistance of *A, B* and *C* is one-third of an ohm. The joint resistance of *X, Y* and Z is likewise one-third of an ohm. In the same manner the joint resistance of lines 1, 2, 3, 4, 5 and 6 is one-sixth of an ohm. The sum of the resistances thus determined is five-sixths of an ohm which is the answer to the problem.

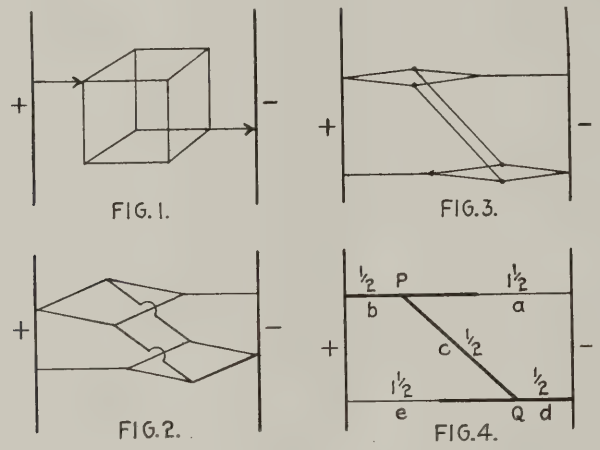
The Algebraic Solution

An algebraic solution of the problem is given in the following paragraphs showing that an entirely different method may be used which arrives at exactly the same result.

There are 12 elements or wires in the cubic circuit, each of which has 1 ohm resistance. We might consider all 12 of these elements but a little consideration will show that an equivalent circuit may be constructed containing but 5 elements. To show clearly how this simplification is effected, four successive wiring diagrams are used beginning with Fig. 1, adding bus bars + and —. The short arrow headed connectors in Fig. 1 are not elements and have no resistance. Fig. 2 is precisely the equivalent of Fig. 1 and contains the same 12 elements. Fig. 3 shows how the diamond shaped loops may be folded and combined. The two diamond shaped loops and the two cross connectors may be flattened out until

Fig. 4 is produced. In Fig. 4 the resistance of each branch has been written in simply from the fact that we know when two elements of one ohm each are placed in parallel the resulting resistance of the combination is one-half an ohm.

Assume that the voltage between the bus bars is V. This is the impressed e. m. f., or voltage. Now represent the current in each branch by the letters a, b, c, d and e. We have five unknown quantities and to determine their values will require that we establish and solve five independent equations. The laws laid down by Kirschoff enable us to establish these equations. His first law states that the algebraic sum of the currents meeting at a point is zero, or the sum of currents flowing toward a point



The Cubical Diagram Simplified to Make it More Easily Adapted To a Mathematical Solution

is equal to the sum of the currents flowing away from that point. Therefore, we may write since the only points to be considered are P and Q.

(1.) $b = a + c$ (2.) $d = c + e$

Kischoff's second law states that the algebraic sum of the "drops" or consumed voltages in any circuit is equal to the impressed voltage. There are only three circuits to consider. First, from + through P to —; second, from + through P, through Q to —; third, from + through Q to —. These "drops" in volts are equal to the products of the currents in and the resistance of the several branches or elements. Thus the first circuit

$$(3.) \quad \frac{1}{2} b + \frac{1}{2} a = V$$

similarly through the second circuit

$$(4.) \quad \frac{1}{2} b + \frac{1}{2} c + \frac{1}{2} d = V$$

and lastly through the third circuit

$$(5.) \quad \frac{1}{2} e + \frac{1}{2} d = V$$

We have thus established five independent equations among the quantities a, b, c, d and e and their solution is as follows: Substitute in (3) the value of b from (1.)

$$\frac{3}{2} a + \frac{1}{2}(a + c) = V \qquad 4a + c = 2V \qquad (6.)$$

Substitute in (5.) the value of d from (2.)

$$\frac{3}{2} e + \frac{1}{2}(c + e) = V \qquad 4c + c = 2V \qquad (7.)$$

From (6.) and (7.) it is seen that $a = e$ and hence $b = d$.

Substituting $d = b$ and $b = a + c$ in (4.) we have

$$\frac{1}{2}(a+c) + \frac{1}{2} c + \frac{1}{2}(a+c) = V \qquad 2a + 3c = 2V \qquad (8.)$$

From (7.), by putting $a = e$ we get $4a + c = 2V$ (9.)

Multiplying (8.) by 2 we get $4a + 6c = 4V$ (10.)

Subtracting (9.) from (10.) we get

$$5c = 2V \quad \text{or} \quad c = \frac{2}{5} V \qquad (11.)$$

It is very simple now to get the values of a, b, d and e

$$a = \frac{2}{5} V \qquad b = \frac{4}{5} V \qquad d = \frac{4}{5} V \qquad e = \frac{2}{5} V$$

Thus we have the values of a, b, c, d and e in terms of V.

If V is one volt, then a is 2/5 amperes; b, 4/5 amperes etc. The total current flowing through the cubic circuit is obviously the sum of b and e or a and d.

Let I = the total current so that $I = a + d$.

Then $I = \frac{2}{5} V + \frac{4}{5} V$ or $\frac{6}{5} V$

Let R = the equivalent resistance, which is the quantity we are seeking, then by Ohm's law

$$I = \frac{V}{R} \quad \text{and} \quad R = \frac{V}{I} = \frac{V}{\frac{6}{5} V} = \frac{1}{\frac{6}{5}} = \frac{5}{6} \text{ ohm.}$$

Answe

W. L. Bliss,
Ch. Engr. U. S. Light & Heat Cor

Questions for April

From a car lighting man in a middle-western cit come a few questions pertaining to his daily task. Wh will undertake to tell him what he wants to know? Som of you who read this column can surely give him th information he desires. Here are his queries:

1. *How would a U. S. L. 100-ampere generator, 15 type panel work with battery connected up wrong; tha is; positive lead to negative side of battery, and negati to positive side of battery?*

2. *Would your generator reverse itself and other par of your equipment; that is, would the positive turn nega tive and the negative turn positive?*

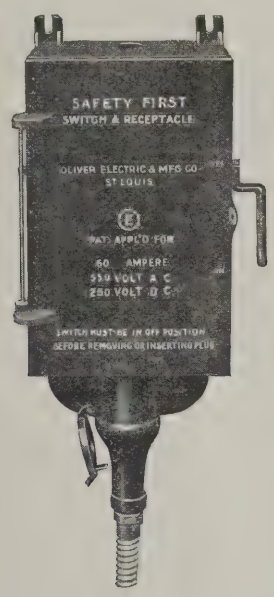
3. *Would your meter read reversed?* *J. A. R.*

Any answer to these questions that are sent to the editor will appear i the May issue.

NEW DEVICES

Safety Switch With Interlocking Plug

A safety first switch with receptacle and interlocking plug has just been placed upon the market by the Oliver Electric & Manufacturing Co., of St. Louis, Mo. The equipment is of a rugged construction, mounted in a non-corrosive cast metal box with overlapping cover. It is intended for use with portable arc welding machines, portable motors, etc., where maximum safety is desired.



Switch with Plug Inserted

The switch and plug are interlocked so that the plug cannot be inserted or withdrawn without the switch being on "off" position. Neither can the switch be opened unless it is in "off" position. Furthermore, unless the plug is completely engaged the switch cannot be closed and when the switch is closed with the plug withdrawn, the cover for the receptacle is locked.

The plug itself is of substantial construction with protected contacts mounted in molded insulation. The plug handle is arranged with coupling for Sprague extra flexible conduit or with bushing for reinforced cord, to take strain off wires.

The switches within the receptacle are furnished with fuse clips at the bottom for N. E. C. cartridge fuses, but the fuses themselves are not furnished with the equipment. The housing of the receptacle is arranged with ground clips which engages the shield of the plug before making contact, insuring positive ground. The receptacle has floating contacts mounted in molded insulation.

Classification and Marker Lamps

Another product that is being marketed by the Oliver Electric & Manufacturing Co. is the electric classification and marker lamp shown in the illustration. These lamps are light and compact, being made of cast aluminum. They are, nevertheless, of rugged construction. All types are furnished with standard Edison base composition socket with lamp grip and extension key, so that the light is controlled from outside of the lamp, making it necessary to turn on the light at the lamp, insuring the display of proper colors.

All types of classification and marker lamps are furnished with mounting bracket to fit the socket now being used for oil lamps. The lamps revolve in the brackets so that they can be placed at any angle desired and are then held stationary. The housing for the lenses is standard on all types of lamps, so that a classification

Type C. L. B. Classification Lamp

lamp can be converted into a marker lamp by removing the color screen throw over device and changing the lenses. The classification lamps are furnished in two types. Type C. L. B. housing has two adjacent standard clear white semaphore lenses 5⅜ in. diameter and two adjacent cast metal blanks with peep holes to indicate whether lamp is burning. This type has a throw over device inside the housing arranged with green color

screen to give color change desired. The type C. L. B. S. housing has the clear white semaphore lenses also, and two adjacent standard green semaphore lenses 5⅜ in. diameter. This type is arranged with blank metal throw over device so that it is necessary to turn the throw over device and the lamp to get the proper colors desired.

The marker lamps are furnished with one standard red semaphore lens 5⅜ in. diameter and three standard green semaphore lenses of the same diameter. The color change desired can be obtained by turning the lamp in the bracket. Both the classification and marker lamps can be furnished with lenses of colors other than those listed if so specified.

A General Utility Insulating Varnish

A black insulating varnish characterized as "General Utility Inco Insulite No. 16" has recently been placed on the open market by the International Paint Corporation of St. Louis.

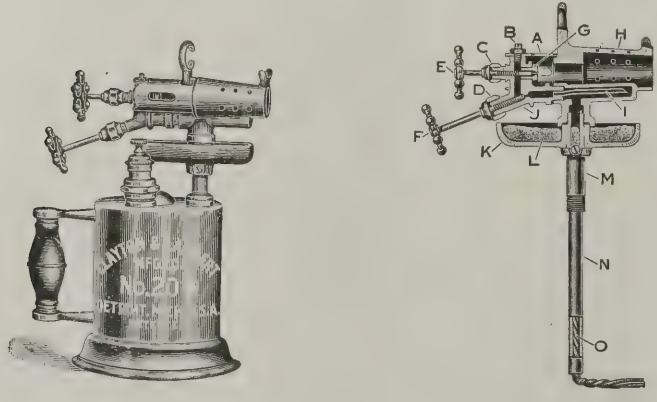
The purpose of this varnish, as its name implies, is to furnish an "all around" product that will efficiently care for a majority of all the insulating varnish requirements of manufacturers of electrical equipment and apparatus, and for repair and re-building shops.

Inco Insulite No. 16 may be either air-dried or baked, with some difference as to uses and results.

The properties and application of this varnish, both air-dried and baked, have been definitely determined, by years of practical use, and by tests just completed in the laboratory. After baking it produces a hard, semi-flexible, jet-black, lustrous coat, possessing a high dielectric strength and electrical resistance, excellent binding and cementing qualities, and is practically moisture, acid and alkaline proof.

Kerosene-Gasoline, Double-Needle Torch

A new type of double-needle blow torch has recently been developed and placed on the market by the Clayton & Lambert Manufacturing Company, Detroit, Mich. The improved double blunt needle construction of the burner, it is said, causes perfect combustion of the fuel and at the same time prevents the vital parts of the burner from

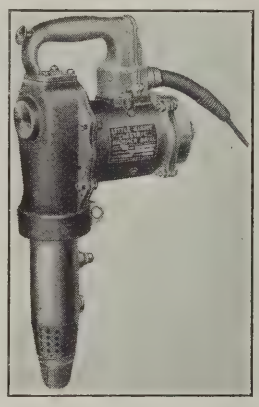


One Quart Torch and Cross Section of Burner

being destroyed by carelessness on the part of the operator. A low grade of gasoline or kerosene or a mixture of both may be used as fuel. Two needles control the supply of fuel which enters the combustion chamber and enable the user to secure the size and quality of flame which is best suited to the work to be done. The upper needle cleans the orifice and cannot enlarge it, and the lower needle is a blunt point shut-off needle and damage to the burner will not be caused by shutting the needle off tightly and allowing the torch to cool. The tank is made of heavy gage reinforced seamless drawn brass and is equipped with an automatic brass pump. These torches are made in pint, quart and two-quart capacities with and without hook and support on the burner for holding a soldering copper. It is claimed they can be used outdoors in any kind of cold or windy weather and they are recommended for brazing, tempering and annealing.

Electric Hammer Drill

A hammer drill, driven by an electric motor instead of compressed air, is being manufactured by The Chicago Pneumatic Tool Company, 6 East 44th street, New York. The drill is known as "The Little Giant Electric Hammer Drill," and is particularly adapted for drilling concrete, soft stone and for light chipping of metals. The hammer blow, which is delivered by a piston on the drill steel or chisel, is produced by pneumatic impact. At the instant the blow is struck, the piston is running free of all mechanical parts and very little shock or vibration is transmitted to the electrical parts of the tool. The tool is so balanced that when held loosely in the hand, the line of center of gravity falls between the third and middle fingers of the hand and lies within the barrel of the tool, causing the tool to hang vertically. The switch is located in the handle. All bearings are of the ball type and provision is made for the lubrication of all revolving and reciprocating parts. The gears and other portions of the moving parts subject to wear are all hardened. A universal type of motor is used which will operate either on direct or alternating currents and motors will be supplied for either 110 or 220 volts.



Little Giant Electric Hammer Drill

A special feature of this drill is a live air device for clearing the hole of the cutting while drilling. The purpose of this device is to keep the hole clear so that when holes are drilled in stone or concrete in a downward position the air will dispose of powdered cuttings which absorb and waste much of the force of the blow and tend to choke up the hole. This makes it possible not only to deliver the full force of the blow on the stone or concrete, but also makes it easy to get the drill bit out of the hole. Hollow steels or bits are furnished for this purpose.

Motor Line Extended

A new type of frame 208 motors has been put in production by the Robbins & Myers Company, Springfield, Ohio. This will bring the company's line of polyphase motors from the 30-hp. size up to 50-hp. and this in turn will be extended up to a capacity of 100-hp.

General News Section

The office of assistant superintendent, West Shore Railroad, Electric Subdivision, has been abolished by an order effective March 16, 1921.

Wireless communication between Japan and America has been extended to the whole of the United States with the inauguration of the high-power sending station at Hara-No-Machi, near Sendai.

The Cincinnati Electrical Tool Company, Freeman Avenue, Cincinnati, Ohio, has been authorized to increase its capital stock from $75,000 to $225,000. The company, it is stated, does not contemplate any immediate extensions.

The Wagner Electric Manufacturing Company, St. Louis, announces the removal of its Boston office and service station to 342 Newbury Street, where it will occupy the entire building. Brooks Faxon will continue in charge as district manager.

Robert M. Feustel, consulting engineer and electric railway operator, advocated the electrification of existing steam roads rather than the construction of paralleling electric lines at a metting of the government commission investigating the proposed hydro-radial system for the province of Ontario, Canada.

President Harding is understood to be planning a trip to Alaska this summer to make a personal study of conditions, including the Alaska government railroad. A plan has been under consideration for completing the railroad as rapidly as possible and for the operation by the government of a steamship line between Alaska and various ports on the Pacific Coast.

The Cleveland Electric Motor Company, 5213 Windsor Avenue, Cleveland, announces that D. Wilson, formerly sales manager for the Electro Dynamic Company, has returned to Philadelphia and will become associated with Harris & Evans, Real Estate Trust Building, in the distribution of the products of the Cleveland Motor Company.

The General Electric Company, Schenectady, N. Y., has completed plans for the construction of its proposed new plant at New Albany, Ind., for the manufacture of electric lamps, to cost about $1,000,000. It will be operated in the name of the National Lamps Works division of the company and will give employment to about 600 operatives.

The Southern Pacific Company has informed the Railroad Commission that it proposes to abandon a material part of the electric service operating over the terminal property at Oakland, Cal. It is proposed to abandon the electric lines and service between the property along Webster Street to and across the drawbridge and over San Antonio estuary; to discontinue the operation of the so-called Fourteenth Street trains now operating between Alameda Mole and the Fourteenth Street terminal property, together with the operation of street cars which are now being run between Alameda and the depot.

The Cutler-Hammer Mfg. Co., Milwaukee and New York, announces the following changes in the personnel of the district office territory: G. S. Crane, who has been manager of the Cleveland office, will become manager of controller sales at the main office at Milwaukee. L. B. Timmerman will be in charge of the Cleveland office, and will act in the capacity of assistant to A. G. Pierce, manager of the central district. The Cincinnati office will become a part of the central district with R. I. Maujer as branch manager. E. N. Lightfoot will assume the title of manager of the heating department with headquarters at the New York works, and will be in full charge of all matters relating to the sale of electric heating devices manufactured by the company.

A plan to remedy the flickering lights on the New York Interborough subway trains was decided upon recently at a conference between the officials and engineers of the traction company and the members and electrical engineers of the Public Service Commission. The commission has received numerous complaints about the inadequacy of the lights on the trains.

The traction company engineers have devised a new contact shoe for the third rail, consisting of a smaller shoe protruding through a square hole in the large regulation shoe and held down by a powerful spring. The theory is that even if the large shoe leaves the rail on account of oscillation of the train, the spring will hold the smaller shoe to a contact and thus provide a continuous flow of current and prevent the flickering of the lights.

The Tax Bureau of New York State estimates that the State income tax yield for 1920 from railroad employees, who were exempt from payment of tax in 1919 on account of government operation of the railroads will amount to $1,000,000. Careful estimates place the total number of railroad employees in New York State during 1920 at over 130,000. The railroads were not turned back to private ownership until March 1, 1920, but the additional revenue is expected from the remaining 10 months. An examination of Federal income tax returns shows that hundreds of thousands of persons are paying federal taxes for the first time and a large percentage in New York State are railroad men. The largest increases in the number of employees on New York railroads took place among machinists, boilermakers, blacksmiths, electricians, air-brake men, car inspectors, car repairers, helpers and apprentices, hostlers and other enginehouse men.

Annual Meeting of American Welding Society

The annual meeting of the American Welding Society will be held in the Engineering Societies Building, 33 West 39th street, New York, on April 27, 28, 29 and 30, 1921. Aside from the meetings of the various committees, a business session will be held at 2 p. m. on April 28, and a technical session at 8 p. m. on the same day. These meetings will be held in room 2 on the 5th floor of the building. The program for the technical session will be as follows:

1. "Applications of the Automatic Welding Machine," P. O. Noble, to be accompanied with lantern slides.
2. "Production Welding with the Gas Flame" (author's name not received in time to be included in program).
3. "Results of Recent Thermit Welding Research," J. H. Deppeler, to be accompanied with lantern slides. This paper will deal with the standardization of thermit welding practice, the cost and method of elimination of defects in thermit welds, blow-holes, shrinkage cavities, etc.

A. R. E. E. to Omit Semi-Annual Meeting This Year

At a meeting of the executive committee of the Association of Railway Electrical Engineers, held in Chicago on April 9, it was decided to omit the regular semi-annual convention of the association this year. The announcement of this decision is not surprising in view of the fact that the Railway Supply Manufacturers' Association are not going to exhibit at the annual convention of the American Railway Association.

Employee Educational Work on the Great Northern

To meet a desire expressed by a number of employees, particularly in the engineering department, for an opportunity to acquire a broader knowledge of railroading than comes to them through the routine work of their own departments, the Great Northern is developing a course of study to be taken up at bi-monthly meetings, in St. Paul, of a class of several hundred employees. The course is designed to cover a period of about six months and the class is open to employees of all departments who are interested.

The extent of the interest is indicated by the fact that over 400 employees responded to the call for the first meeting. Interest in the plan is also developing among employees at outlying points and consideration is being given to means of extending it. This work had its inception among employees and officers at the headquarters of the road at St. Paul. Consideration is also being given to the development of a course of study that will meet the special requirements of interested employees in the mechanical department.

Western Electric Increases Pensions

The Western Electric Company has just announced a broadening of its pension policy. Employees who have been with the company but who have been pensioned because of disability may also be benefited under a more liberal ruling. The pensions given are of four classes. They are given to male employees who have served twenty years and who have reached sixty years of age and to women with the same amount of service who have reached fifty-five years. The second class includes all men aged fifty-five and women of fifty who have served twenty-five years. The third class is based upon thirty years of service with no limitations on account of age. In the fourth class are those who have been totally disabled by reason of sickness after fifteen years with the company. The annual pension in all four classes is one per cent of the average annual pay for ten years, multiplied by the number of years in the employee's term of service. Workers coming under the first three classes are assured of a life income of at least thirty dollars a month under the new ruling.

Making the Radio Telephone Popular

The Westinghouse Electric & Mfg. Co. have established a radio telephone station at East Pittsburgh where experiments are being carried on for the purpose of popularizing the wireless telephone. Each evening a program is sent out from this station which can be heard at distances up to 1,800 miles. The program usually consists of phonograph selections, vaudeville sketches from the theater and selections from well known singers. The Sunday program includes church service from the Calvary Church. Short wave receiving sets can readily hear this station and radio amateurs have sent in letters from points as far distant as Warren, Ariz.; Denver, Colo.; Deland, Fla.; Ellendale, N. D., and Montreal, Canada, in which they state that these concerts are heard and enjoyed practically every evening. The latest news is sent out to persons living in rural districts who are thus enabled to learn of current events much sooner than would otherwise be possible. Speeches of prominent men visiting Pittsburgh are given out to thousands in this way by concealing transmitters in baskets of flowers located on the speaker's table.

Electrification Plans for Italy

A report from the Ministry of Public Works at Rome announces that a special department has been established for the purpose of giving careful study to the development of all of the water power resources in the country. So far only two-fifths of the water power available has been utilized for industrial purposes. About $160,000,000 has been appropriated by the government for the purpose of pressing into service all of its water power resources, and thus extending electrification over the entire country. It is estimated that approximately 2,000,000 tons of coal can thus be saved annually. The electrical power developed by the hydro electric plants will not only be used for Italian industries but also for the electrification of the railroads.

Navigation Protected by Wireless

Secretary of Commerce Hoover recently made the announcement that the development of the radio compass by the Bureau of Standards would immediately lead to the installation of three wireless stations at the entrance of New York Harbor through the lighthouse service. Each of these three stations is equipped with an automatic radio sending set, to send out signals continuously during fog. These signals are picked up on board ship by means of the new radio compass which indicates the direction from which the signals come. By observation on the different stations, the captain of the

vessel is thus enabled to determine his position without resorting to the unsatisfactory method of listening to the sounds of whistles and fog horns. The lighthouse service plans to establish other stations as soon as necessary appropriations have been made for this purpose. The system used differs from other systems in that the navigator is able to determine his exact bearing by means of the radio compass in the same way as he uses a magnetic compass in clear weather, and is at no time obliged to depend on expert radio operators.

Progress of Electrification of French Railroads

The work of electrifying certain French roads, which started in 1920, has made rapid progress. The Midi Company has 93 miles of double track electric line in operation and the work of electrifying a further 1,800 miles of track belonging to this road is actually in progress. The reconstruction of two hydro-electric plants, which will furnish 150,000 hp. each to this road, is nearly complete. The road has placed orders for 50 new electric locomotives of the type used by the Chicago, Milwaukee & St. Paul.

Two other French railroads have undertaken the electrification of sections of their line, the Orleans, which is electrifying 1,800 miles, and the P. L. M., which also is electrifying 1,800 miles of road. The electric power for the Orleans road will be furnished by the water falls of the Upper-Dordogne, and for the P. L. M. by the falls of the French Alps. The cost of electrifying these roads will be in the neighborhood of 5,000,000,000 francs. The saving in coal is expected to exceed 3,200,000 tons per annum.

President Harding Phones to Cuba

The formal opening of telephonic communication between the United States and Cuba was celebrated on April 11, when President Harding exchanged greetings with President Menocal of Cuba.

The event took place at the Pan-American Building under the auspices of the National Press Club. President Harding's greeting was as follows:

"I want you, President Menocal, and the government and people of Cuba to know how gratifying it is to participate with you in this ceremony, which signifies so much in the establishment of more intimate and understanding relations between Cuba and the United States. This time is especially auspicious for the exchange of assurances that our two republics are bound together by indissoluble ties of sympathy and interest. Our fortunes have been linked together already in two history-making struggles, and today, when Cuba stands under the shadow of a national misfortune, I want you to know that the United States is determined as always to prove itself the true and helpful friend of your nation."

The engineering features of the telephone cable to Cuba were explained by Colonel J. J. Carty, vice-president of the American Telephone and Telegraph Company, who said that problems which had been confronting science for years had been solved in the construction of the long submarine line. He said the conversation heard today equaled a talk from London to Paris and many miles further, or from London to Calcutta. Using the same telephonic energy, a conversation might be possible from scuCrunu5g etaoin shrdlu shrdlu mm mm shrd mmmm points in the United States to Santiago, Chile.

Other Foreign Electrification

The Bukarest government is considering the electrification of a number of its railroads. Orders have already been placed in Germany, the Orenstein-Koppel Works alone having received orders to the amount of 90,000,000 marks. It is reported that additional orders will be placed in the near future.

Electrical Show in Armory

After considerable uncertainty over the selection of a suitable building it has been announced that the New York Electrical Exposition will be held at the 71st Regiment Armory, Park avenue and 34th street, New York, during the ten days beginning September 28.

With the Grand Central Palace no longer available for exposition purposes the show management was confronted with the problem of finding a place that combined suitable floor arrangements, facilities for handling the exhibits, and accommodations for spectators. The success of other shows that have been held in armories indicates that the requirements of the Electrical Show will be well met by the 71st Armory.

As in former years, the 1921 show will feature electrical equipment for the home, motor driven machinery for industrial purposes, electrically operated material handling machinery, and electric vehicles.

Personals

Ralph G. Coburn, president of the Stone Franklin Company, New York, has been elected also a vice-president of the Elvin Mechanical Stoker Company with headquarters at 50 Church street, New York, and E. W. Englebright, who became associated with the Elvin Mechanical Stoker Company in December, 1920, has also been elected a vice-president of that company. Mr. Coburn was born in Boston in 1882 and was graduated from Harvard in 1904. He then served, until 1909, with the American Glue Company in charge of its western territory, with headquarters at Des Moines, Iowa, and Chicago. On May 1, 1909, he opened the Chicago office of the Franklin Railway Supply Company as resident sales manager and in June, 1911, was appointed assistant to the vice-president in charge of eastern-southern territory, with headquarters at New York. In December, 1913, he was appointed eastern sales manager of the company. In May, 1919, the Stone Franklin Company, New York, was organized to market the Stone Franklin car lighting system in the

R. G. Coburn

United States and Canada and Mr. Coburn was elected president of the new company, which position he still retains in addition to his new duties as vice-president of the Elvin Mechanical Stoker Company.

P. J. Tracy, formerly electrician at Kansas City, has been placed in charge of a new car lighting station which the Atchison, Topeka & Santa Fe Railway Company has opened up at Ash Fork, Ariz.

Frank Zimkowski, general car lighting inspector, New York, New Haven & Hartford, has had his jurisdiction extended to include the supervision of all locomotive headlight maintenance.

James W. White has joined the sales organization in the New York office of the Okonite Company, Passaic, N. J. Mr. White was formerly in the service of the General Railway Signal Company for four years and then with the Union Switch & Signal Company for about five years.

W. H. Holdorf has succeeded A. L. Frankenberger as the railroad representative of the Western Electric Co., with headquarters in St. Paul. Mr. Holdorf has been in the electrical business since 1908, eight years of which have been spent with the Western Electric Company.

Frank Conrad, consulting engineer of the Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., has been appointed assistant chief engineer. He has been connected with the Westinghouse organization for almost thirty years, having joined the company when it was in its first location at Garrison Alley.

A. J. Manson, has been appointed manager of the railway division, New York office of the Westinghouse Electric & Manufacturing Company. After graduating from Massachusetts Institute of Technology in 1905 he entered the company's engineering apprenticeship course. He was active in the electrification of the New Haven Railroad and the Pennsylvania Railroad into New York City and during the past few years has been connected with the sales organization in New York.

Readers of the *Railway Electrical Engineer* know Mr. Manson from his numerous contributed articles which have appeared from time to time dealing with various phases of heavy electric traction.

Trade Publications

The Cincinnati Electrical Tool Company, Cincinnati, Ohio, have recently issued a new catalogue covering its complete line of portable electrical drills, grinders and buffers, including several new type machines which they have recently brought out.

Ward Leonard Electric Company, Mount Vernon, N. Y., has recently issued a four-page folder known as Circular 503 in which are illustrated and described 32-40-volt plant accessories. Charging rheostats, resistance units and light dimmers are among the equipment listed, sizes and prices being given in each case.

John C. Dolph Co., Newark, N. J., has recently issued a new edition of its catalogue describing the "Dolph" insulating varnishes and compounds. A great variety of varnishes is described and the correct method of using them is fully outlined. At the close of the 32-page booklet complete directions are given for the application of varnish to armatures, coils and field coil by the dipping and baking process.

Crouse-Hinds Company, Syracuse, N. Y., is distributing a large folded mailing piece entitled "Safety First is Efficiency First." The folder describes and illustrates with several photographs the ZY series of "Condulets." The condulet of this series consists of a cast iron housing which contains a combined snap switch and fuse block. The switch is externally operated, and its handle interlocks with the latch of the door so that the door cannot be opened when the switch is in the "on" position.

The Goodell-Pratt Company, Greenfield, Mass., has recently issued tool book No. 14 containing 464 pages, 6 in. by 9 in. A detailed index of the fifteen hundred tools manufactured by this company is included in the front of the book, together with general information regarding design, making and inspection. List prices given in this catalogue were effective on January 1, 1920, and are subject to change without notice. For the convenience of mechanics and others who find the 6 in. by 9 in. book inconvenient to carry, a pocket edition with 3½ in. by 5½ in. pages is available.

C-H Electrically Operated Brakes are described and illustrated in a 16-page, 8½ x 11 booklet with the above title, and published by The Cutler-Hammer Mfg. Co., of Milwaukee, Wisconsin. Tables give dimensions and ratings of each type of brake, and it is explained how the correct size of brake for any particular installation may be calculated. The direct current shoe brake is described as being very compact. Its rigid construction and few moving parts make it adaptable for the most severe service. The alternating current brake operates by means of a rotating magnet, which largely eliminates noise and wear. A disc brake adaptable to special installations is also described. Installation views of these brakes on cranes, hoists, elevators, and other machines are shown.

The General Electric Company, Schenectady, N. Y., has issued a number of bulletins as follows: *Industrial Haulage,* Bulletin No. 44251.—This is a profusely illustrated 36-page pamphlet which describes trolley, third rail, storage battery and combination trolley and storage battery type industrial locomotives. *Wires and cables.*—In one binding under this title are contained Bulletins 49305 to 49309 inclusive which supersede Bulletins No. 49300-1-2-3-4. The pamphlet deals with the development and use of underground cables and also goes into the choice of cables, gives tables of capacities, test voltages and dimensions and classifications of cables. *Small Turbo-Generator Sets,* Bulletin No. 42010A, superseding No. 42010.—This describes a number of turbo-generator sets for stationary plants, for train lighting and for use on board ship. *Small Capacity Industrial Oil Circuit Breakers,* Bulletin No. 47419A, superseding 47419.—This is a 17-page bulletin which describes circuit breakers equipped with automatic and non-automatic control. It is profusely illustrated and includes dimension drawings as well as diagrams showing various methods of making connections.

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The Economies of Electrification

In the current issue of American Railroads, published by the Association of Railway Executives, R. H. Aishton, president of the American Railway Association, states that the railroads have been making economies and working for increased efficiency in every possible direction. Wages are not the only expense which they have sought to reduce. Mr. Aishton states that of the 65,000 locomotives in the United States approximately 35,000 of them have been equipped with superheaters, 43,000 with brick arches, 37,000 with automatic firedoors and 15,000 with power reverse gears. All of these locomotives have been equipped with the so-called modern devices in the comparatively brief period of 10 years, but, says Mr. Aishton, "Such improvements require large amounts of capital. For instance, let us say, it is an economy to buy high power locomotives which will haul longer freight trains. In order to get this economy it may be necessary to build new roundhouses, larger turntables, enlarged coal facilities, greater erection pits for repair work, longer sidings for these trains to pass on, more extensive yards for them to be made up in and broken again, larger terminals and longer platforms."

It is interesting to note in this list of necessary expenses involved in the use of modern locomotives, that many of them can be absolutely dispensed with when electric power is used to solve the problem. On page 195 of this issue the writer of the article "Characteristics of the Electric Locomotive" brings out the facts clearly in a single paragraph which is as follows: "Many of the old ideas that have grown up around the steam locomotive will have to be modified or abandoned and new methods introduced. The length of engine divisions, ruling grades, distribution of coal and watering stations, dispatching, the tonnage and speed of trains, the design of stations and terminals, have all hinged around the steam locomotive. This revolution will not have to take place all at once—it will be rather a gradual evolution of two methods that will be worked up by the more progressive operators, as the advantages and possibilities of electrification develop before them."

If the modern steam locomotive requires such expensive facilities for its proper care, if it is necessary to build larger new roundhouses, if larger turntables are required, if greater coal facilities are necessary, if all of these things which are necessary to the modern steam locomotive must be installed before the so-called economies of this inefficient motive power unit begin to make themselves manifest, then—why not adopt the electric locomotive, why not lengthen the engine division, why worry about ruling grades, the distribution of coal and watering stations, or the tonnage and speed of trains? Why not employ the motive power unit that has double the pulling power of the steam locomotive? In a word, why not give the electric locomotive the consideration it deserves and begin as soon as practicable to enjoy the economies of electrification?

Enginehouse Lighting

Enginehouse lighting is probably the most difficult lighting problem on the railroad. As practically all lighting is electric this becomes a problem for the electrical man. In the first place, the spaces between locomotives are long and narrow, and practically everything in the enginehouse is black and does not spread and diffuse the light from its source. An added difficulty is the necessity for placing the lights in such a position that the light will not actually interfere with the work in progress or make it difficult for the hostler to spot locomotives properly. There should also be an adequate number of extension outlets. The gas given off by locomotives is particularly damaging to conduit and to practically all kinds of metal fittings, and for this reason it is desirable to have all conduit, reflectors, cabinets, switches, etc., below the gas line, provided this does not interfere with the results obtained by the lighting. If the reflectors are not placed in a fairly low position, the smoke blackens them and reduces their efficiency quickly. There are three articles in this issue of the *Railway Electrical Engineer* which deal with a newly developed system for the lighting of enginehouses. The features of the system are a special type of reflector and the method of mounting these reflectors in pairs so that the beams of light from each pair are crossed. The articles include a general treatise on the use of this method of lighting and a description of actual installations, together with the results obtained as expressed by the users. The method may and may not prove to be the best one available, but it is a good one and well worth the attention of all those interested in this subject. It complies with requirements in that it makes it possible to keep all the outlets and wiring which are located inside the enginehouse below the gas line, and

gives a well diffused light which lights up the running gear of the locomotives where most of the work in the enginehouse is done.

Lighting Fixture Cleaning Periods

The cleaning of electric lighting fixtures is unquestionably a most important operation. For every lighting installation there is a definite economic interval which should elapse between the cleanings. Seldom, if ever, will this interval be exactly the same for any two installations. Fundamentally, the most economic interval is determined by offsetting the cost of the cleaning by the loss from decreased illumination. The expense of cleaning is comparatively easy to compute, but the loss from decreased illumination involves so many variable factors that it is by no means a simple proposition to determine. Of all the losses incurred through poor illumination, there is little doubt but that the greatest is the loss due to decreased output by workmen on account of poorer light. The cost of cleaning the lamps should be accurately determined once and for all, and be used as a basis of comparison. The exact interval between the cleaning periods will be different for each installation; probably from one to six weeks. The length of the interval also depends upon the kind of fixtures, their location and the character of the work performed in their vicinity. About the only satisfactory way in which to test quality or quantity of light derived from any lighting unit is by the use of some form of a foot-candle meter. After having carefully experimented with such an instrument and given due consideration to the cost of cleaning, the length of the interval between cleanings may be made more scientifically correct. There are altogether too many haphazard and rule-of-thumb methods used in the maintenance of lighting systems and in almost every instance the reason behind this improper care is the lack of knowledge as to how it should be done. Why not maintain your lighting system by correct scientific methods?

Will You Be Thrifty Then?

It is said that the world is "turning a corner" which means, when put in less figurative language, that its inhabitants are passing through a period of unbalanced conditions which gives evidence of continuing longer than any similar period that the world has ever known. It is altogether likely that the very duration of the period will do more than any other one thing to reduce to a minimum the discomfort caused by the downward trend of wages and prices.

Unlike the time of Joseph, with his interpretation of Pharaoh's dream, we have not experienced quite seven years of plenty, but certain it is that from the time war orders began to filter into this country in the latter part of 1914 until early in 1920, the flow of money into the pockets of the people of the country was so great and continuous that it seemed as if the golden stream would never stop. A great many people thought it never would. At any rate they proceeded to spend accordingly. Luxury upon luxury began to make its appearance among classes of people who had never before dreamed of possessing such things. Pleasure after pleasure was added to the mad whirl of hysterical spending by the former poor class. It was wonderfully pleasant while it lasted, but alas, for the improvident ones, it was not destined to continue indefinitely. In the midst of all this orgy of spending some, a very few, had sense enough to be thrifty. They realized that such abnormal incomes could not continue indefinitely and providently laid aside out of their abundance generous portions for the inevitable "rainy day." Now that the rainy season is upon us the wisdom of preparing for it is apparent to all, but unfortunately for the majority, the vision comes too late to be of any practical benefit except to emphasize one particular thing—the need for thrift.

Thrift may be defined as frugality or economy in management, but what it really amounts to is preparation in the time of plenty to obtain necessities in the time of scarcity. Properly practiced, thrift will keep a man's financial boat on even keel. He may not have every luxury he may desire when times are good, but what is tremendously more important, neither he nor his family will have to forego every comfort when times are bad. There is no use of denying the fact that we are facing a period of lower costs and lower incomes. To deceive ourselves into thinking differently is worse than futile and will get us nowhere. It is hard to accept the truth, but our reluctance to accept it cannot change the facts in the least. The thrifty man does not worry about tomorrow, but he who is not thrifty will have more than one occasion to ask himself, "What did I do with that back pay?"

Things are not as bad as they seem and when the many economic wrinkles have been ironed out and the dollar has returned to its original value of one hundred cents, the biggest question that will confront you is, will you be thrifty then?

New Books

Electric Welding. By Ethan Viall, 6 in. by 9 in., bound in cloth, 399 pages of text, illustrated. Published by the McGraw-Hill Book Company, Inc., 370 Seventh avenue, New York.

The book has been compiled as a permanent record of electric welding as it is today and is written for the use of those engaged in welding practice and as an aid to research and development. The 17 chapters deal with the following subjects: history of electric welding, arc welding equipment, different makes of arc welding sets, training arc welders, carbon-electrode arc welding and cutting, arc welding procedure, arc welding terms and symbols, examples of arc-welding jobs, physical properties of arc-fused steel, metallography of arc-fused steel, automatic arc welding, butt-welding machines and work, spot-welding machines and work, welding boiler tubes by the electric resistance process, electric welding of high-speed steel and stellite in tool manufacture, electric seam welding, making proper rates for electric welding, and the strength of welds. There are 329 illustrations used in presenting the subjects. Another book by the same author, brought out simultaneously with this one, deals with gas torch and thermit welding.

New Type of Enginehouse and Turntable Lighting

Satisfactory Results Given by Use of Reflector Units Mounted Below Gas Line

By F. M. Evans
American Lighting Company, Chicago

THE recent developments of lighting units using glass reflectors will no doubt receive a great deal of consideration. Evidently there has never been a universal standard method for the wiring of enginehouses

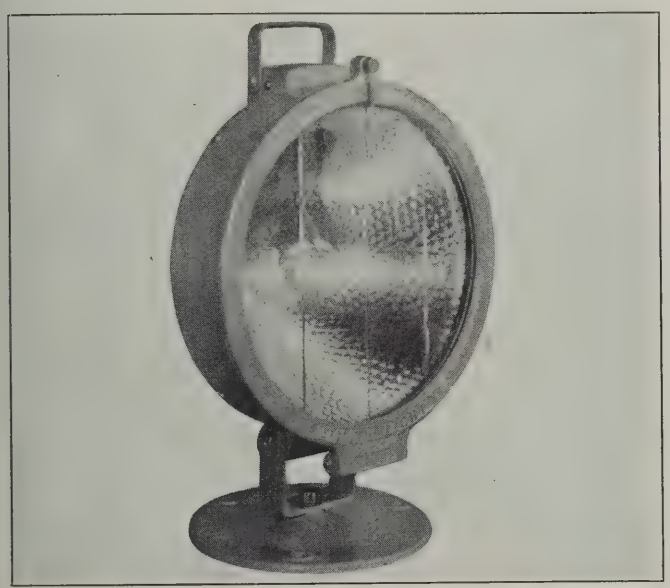
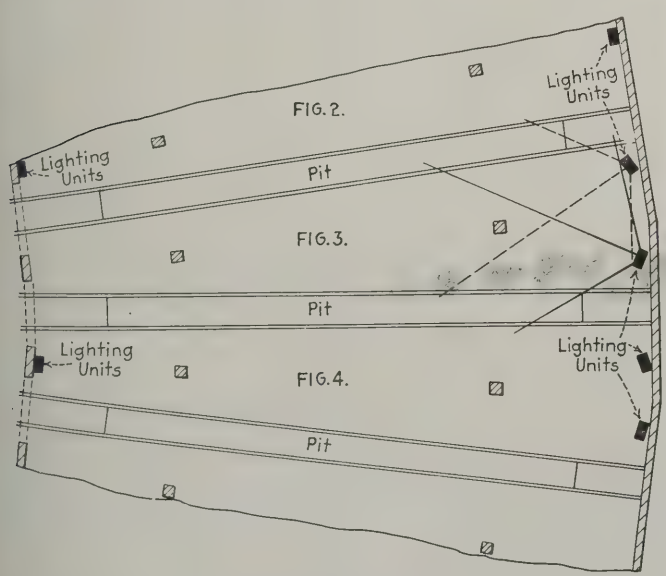


Fig. 1—One of the Lighting Units

and turntables. Many of the roads use the overhead system suspending lamps with reflectors from the ceiling



Figs. 2, 3 and 4—Three Arrangements of Lighting Units for Enginehouse Lighting

or overhead structures. Under normal conditions the elements in the engine smoke are very destructive, resulting in the short life of the metal reflectors. On account of the reflectors being mounted near the top of the building the smoke and dust accumulating rapidly diminishing the efficiency of the illumination and due to the difficulty of reaching the reflector the cleaning was often neglected.

The average reflector produced a blinding glare, illuminating some parts intensively and leaving the distant corners in semi-darkness. As a result of the inefficiency of the overhead system, numerous drop lights with flexible cord connections have been used to illuminate special work on the locomotives. Considerable difficulty is experienced in suspending this single lamp close enough to the work and at the same time not throwing the glare into the workman's eye or a shadow on the work itself.

The problem of roundhouse lighting then resolves itself into the requirement of a system that will meet the following conditions: a lighting unit not easily affected by engine gases; one that is readily cleaned and main-

Fig. 5—The Side of the Locomotive is Well Lighted

tained and equipped with a reflector that will produce an even light without a glare.

With these requirements in mind, a new type of lighting unit called a utility light shown in Fig. 1, has been developed. The body of the unit is made of cast iron while all the fittings and screws are brass to prevent rusting or setting in the casting. The reflector is made of glass which has a surface like that of sheet metal which has been hammered with a ball peen hammer. This produces many small reflectors and results in a distribution of the light rather than a glare. The reflector being glass is readily cleaned and is not attacked by the smoke gases. A wired glass front is used, preventing the glass falling out in pieces if broken by accident. The front is hinged at the bottom and locked at the top

by a hand latch, thus simplifying the maintenance and securing a weather proof unit. The base plate and fittings may be so adjusted as to permit the lighting unit to be mounted in various positions.

Location of the Lighting Units

The lighting unit in each case should be mounted about 12 ft. from the floor, care being taken not to tilt the rays toward the floor but rather to keep the axis of the rays in a horizontal line. Any one of the three methods may be used for lighting the roundhouse stalls: Fig. 2 shows the first method of using one lamp unit at each end of the stall; Fig. 3 shows two lamps at the wide end of the

Fig. 6—Effect Obtained With Two Units on the Outer Circle and One on the Inner Circle Between Stalls

stall, while in Fig. 4 there are two lamps at the wide end and one at the narrow end.

Some idea of the results of this type of roundhouse illumination may be had from the illustrations, Fig. 5 and 6, reproduced from photographs taken at night.

At this point it may be well to consider the accessibility of the apparatus installed in this manner. All the equipment and wiring may be located within easy reach of a man on a short ladder. Such an installation will produce economy and insure better maintenance.

For the illumination of any particular part of a locomotive, this new lighting unit may be used as a portable unit placed on the floor or mounted on a nearby support with the results illustrated in Fig. 7. The efficiency of the workman is increased in that he is not obliged to use

Fig. 7—As a Portable Unit the Utility Light Can Often Be Used to Better Advantage With the Ordinary Extension Lamp

one hand to hold a torch or hand light, and at the same time this system reduces the theft of lamp bulbs.

Turntable Lighting

Turntable illumination requires the uniform lighting of rather a large area without any means of local support

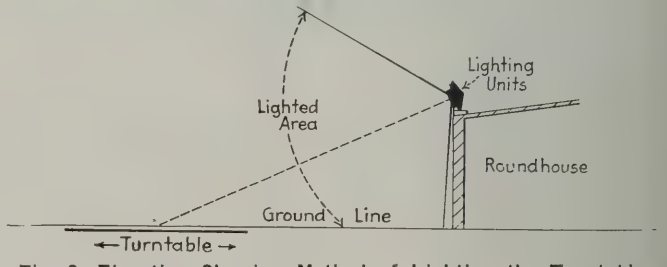


Fig. 8—Elevation Showing Method of Lighting the Turntable

for the lighting units. One very good system in use is to mount the lighting units on the edge of the roof of the roundhouse, as shown in Fig. 8, using one lighting unit

Fig. 9—Lighting Effect Obtained With Four 200-Watt Units

for every four or five stalls for a 12 to 25 stall house up to a maximum of 12 lights for a complete circle. See Fig. 10. By installing the units, as shown in Fig. 8, directing the rays toward the center of the table, sufficient light is distributed over the entire area so as to allow the engineman to see at a glance if the turntable is properly lined up. This illumination is made possible by

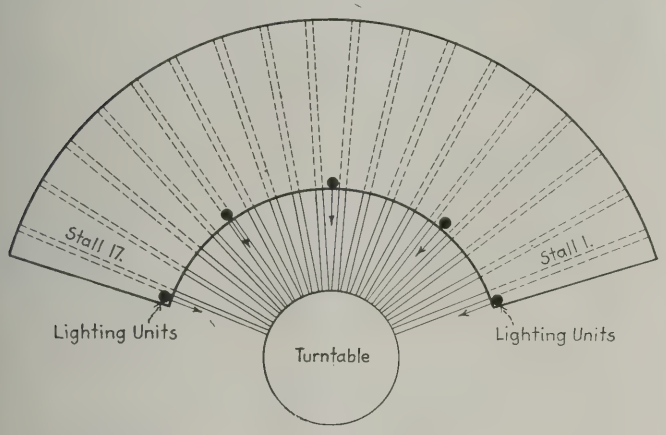


Fig. 10—Plan Showing Method of Lighting the Turntable

the divergence of the light rays which have a spread of 72 degrees. The illumination as shown in Fig. 9 was furnished by four 200 watt utility units.

The engineering and field work of the system described herein was handled by the author and the lighting units were developed by the Western Electric Company.

Enginehouse Lighting on the Boston & Albany

An adaption of lighting units, similar to those described in the previous article, is now the standard method for lighting enginehouses on the Boston & Albany. The lighting units used on the Boston & Albany are identical with those previously described, except that the wire glass in the front of the unit has a frosted circle or disc. in the center, which diffuses the direct rays from the filament of the type C lamp.

The lighting units are mounted in pairs on the outer circle wall, 10 feet above the floor, as shown in Fig. 1. These units are mounted at a slight angle to the wall so that the beams from the two lamps shown are crossed. Usually these units are mounted 7½ feet each side of the center line of the track but this distance may vary, depending upon the distance between tracks and the position of the supporting columns or posts between the tracks. The lamps are 100-watt type C Mazda lamps as against the 400-watt lamps which were found necessary with the old overhead arrangement. This means a considerable saving in the amount of current used. The lighting, however, is very effective due to the crossed beams, the diffused light and the efficiency of the reflectors. The general effect of the lighting obtained is shown in Figs. 2 and 3.

Wiring

The wiring which is all in rigid metal conduit is extremely simple and very little of the conduit is subject to the corrosive action of the gases given off by the locomotives. None of the exposed conduit inside the enginehouse is more than ten feet above the floor line.

Power for lighting is brought to the roundhouses on three wires as single phase 110-volt, 220-volt current.

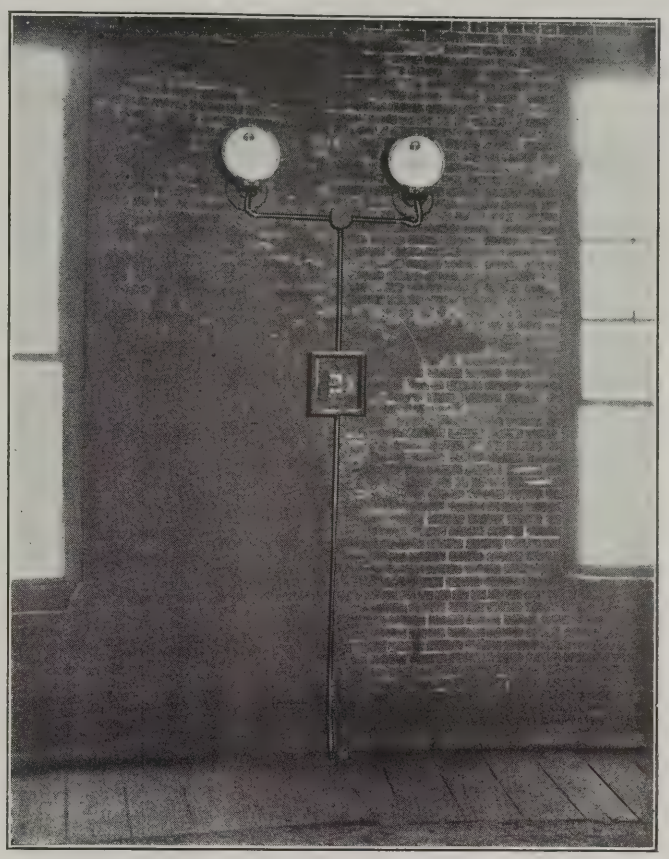


Fig. 1—The Units are Mounted In Pairs On the Outer Circle Wall, 10 Feet Above the Floor

The feeders are run on the outside wall just under the eaves.

With the old type of wiring, these feeders were carried on brackets, as shown in Fig. 4, and the branches

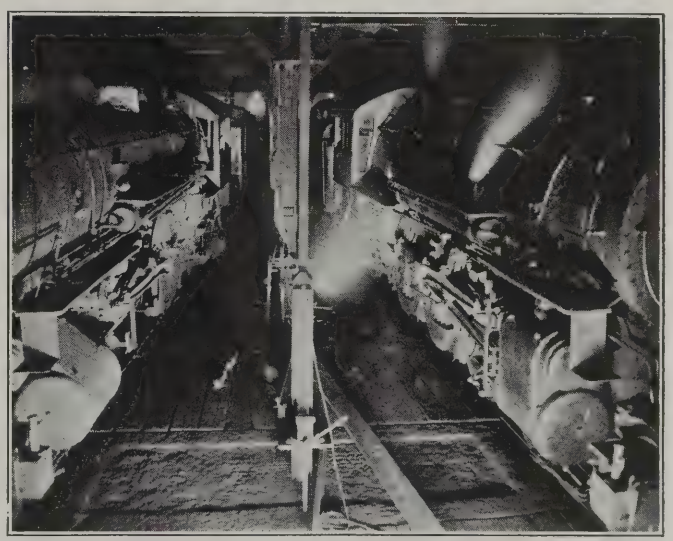


Fig. 2—The Crossed Beams Afford Good Light on the Moving Parts of the Locomotives

carried in to the enginehouse through type F condulets and conduit. These feeders were frequently broken by ice from the roof which was also the cause of their being

dragged down, as shown in the illustration. They are being removed and replaced by three No. 6 rubber covered wires run in 1¼-in. conduit, also shown in Fig. 4. The same branches are used except that the type F condulet is removed and the conduit extended to the junction box just above it. The branches are ¾-in. conduit through which are run two No. 6 wires to the

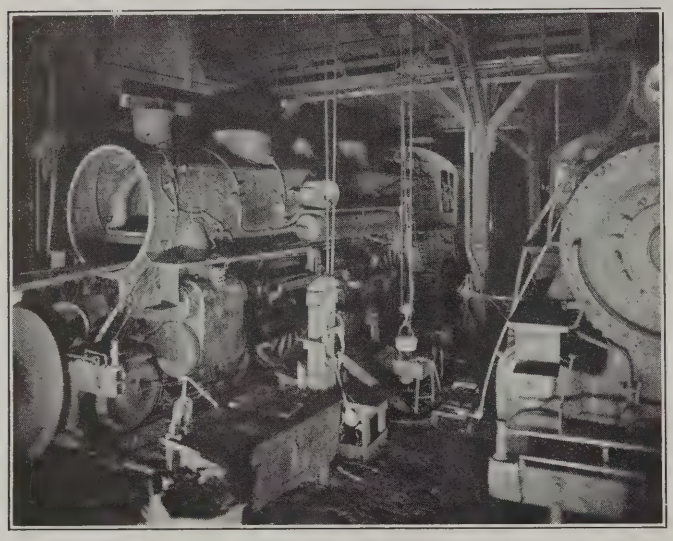


Fig. 3—The Spread of the Light is Great Enough to Light an Open Front-End

switch cabinet, shown in Fig. 1. An elevation of the wiring scheme is shown in Fig. 5.

Each switch cabinet contains a 2-pole, 2-way, fuse block and a double pole snap switch. One circuit supplies the flood lights through the snap switch and the other supplies the extension outlet located on the posts between the pits. No. 14 rubber covered wire is used for both branches run in ½-in. rigid metal conduits.

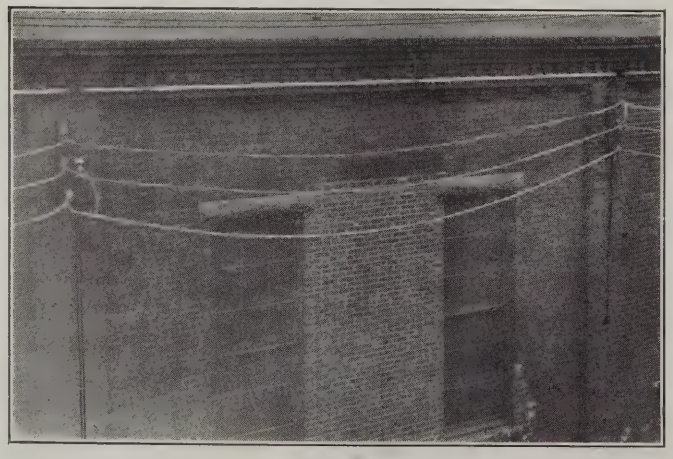


Fig. 4—The Old Open Feeders Are Being Replaced by Feeders Run in Conduit

The branch to the flood light runs straight out of the top of the switch cabinet to a 3-in. junction box with a blank cover where it branches each way to the two flood lights. The ends of the conduit are fitted with conduit bushings, no condulets being used for this purpose.

The conduit for the extension receptacles is carried directly out of the bottom of the switch cabinet, as shown in Fig. 1 and Fig. 5, and is run in the earth to the first post where it is brought out, as shown in Fig. 5, to two Edison receptacles one on each side of the post. The wires for the receptacle on the far side of the post are run through a piece of conduit placed in a hole bored through the center of the post. The run of conduit, which extends to the inner circle post, is run from the receptacle on the outer post down to the earth and up the inner post to the two receptacles located there. The enginehouse has a concrete floor.

The expense of installation was reduced to a minimum by using as much as possible of the old equipment, the cabinet, fuse block, switches, extension receptacles and

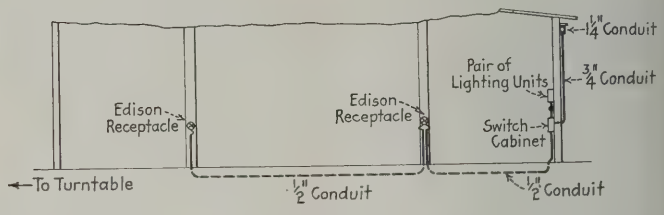


Fig. 5—Cross Section of Enginehouse Showing One of the Branch Runs From the Feeders to the Floodlights and Extension Receptacles

some of the wire and conduit from the old system were used in the new.

F. B. Freeman, chief engineer, Boston & Albany, speaks of the results obtained as follows: One of the greatest troubles with the old form of lighting was the rapid accumulation of a black coating on the exposed lamp due to the damp, dirty atmosphere and the heat generated in the lamp itself. This rapidly lowered the amount of light emitted and due to the height above the floor, cleaning of the lamp was much neglected, the lamp being so high up, the rising steam and vapor which hung against the roof also diminished the amount of light. With the new arrangement, the lamp is not exposed to the damp atmosphere and so cannot get a deposit of dust on it. The plain glass front on the flood light flood being only ten feet from the floor is easily gotten at with a hand ladder and can readily be kept clean. It is also found that the new lights are sufficiently low so that the steam accumulating in the house is usually above the line of light.

It was thought at first that trouble might be experienced with men running engines into the house due to the glare, but this has not developed. The beams of light from the two flood lights crossing each other break up glare and diffuse the light very satisfactorily over the stall and light up all the moving parts of the engine extremely well. The first installation was made in the Beacon Park house, Boston, Massachusetts, and it has proved so satisfactory to everybody that all the houses on the road are now being equipped with the new system as rapidly as possible.

The Eastern Region of the Pennsylvania Railroad in January broke all records for punctuality since the company resumed the management of its property March, 1920. Of the total of 81,713 trains run 91.7 per cent arrived at destination on time and 95.8 per cent made schedule time. In January last year only 77 per cent of the trains were on time and 87.4 per cent of them made schedule time.

Enginehouse Lighting on the Lehigh and Hudson

A ROUNDHOUSE on the Lehigh and Hudson at Warwick, N. Y., has been equipped with a lighting system using the utility units described in the two previous articles with very satisfactory results. The lights were installed under the supervision of C. H. Bennett, signal supervisor, who spent considerable time and ran a number of experiments for the purpose of obtaining the best results possible. The units are mounted on a steel bracket 13½ ft. above the floor, and Mr. Bennett claims that the additional foot and a half materially aids the illumination obtained and reduces the difficulty of the engineer who brings the engine into the engine house. At the 13½ ft. height, he claims that with the slight tilt, the light is better distributed and does not affect the engineer's eyes as at the 12 ft. height, which he states is in exact line with the man in the cab. As with the Boston & Albany installation, two lighting units are placed at the large end of the stall, so mounted that the rays are crossed. With this installation the light extends beyond the turntable and with the doors open there is no need of separate units on a roundhouse for lighting of the turntable.

Mr. Bennett has also observed that unless the lamps are placed correctly in the units that uniform results will not be obtained; that is, the position of the filament with respect to the reflector has considerable effect on the efficiency. The filament of the 100 watt lamps is small and comes off in zig-zag shape from the two lead-in wires. If the filament is placed toward the reflector and the center of the filament in the center of the reflector, with the two lead-in wires toward the front glass, the best results are obtained. If these lead-in wires are turned toward either side of the reflector, the reflector will have a dark or dead appearance.

During the day, Mr. Bennett states, the inspectors use a hand torch on the engines over the pit, but when the lighting system is in service the torch is found to be unnecessary. The light is so well diffused that the men can work in the pit on most of the jobs without the necessity of a hand lamp. In addition, the current consumed is materially reduced and better general lighting is the result. The breakage in hand lamps has been reduced more than 25 per cent.

France to Develop Tidal Power

THE much-discussed plan to develop tidal power in France has been brought nearer to realization by the inclusion in the budget of the Minister of Public Works of an item appropriating 2,500,000 francs for the construction of machinery at the mouth of the Rance River with this object in view. The plan is simple. The Rance has a 30-ft. tide. Enormous reservoirs will be constructed into and out of which tide water will flow through openings holding turbines. When the tide rises the turbines will turn, and when the tide runs out they will also be kept in revolution.

"France must use all her natural forces," the Minister of Public Works said in support of the proposed appropriation. "To the white coal of our mountains and the green coal of our fields we are going to add the blue coal which the length of our seaboard renders available to an enormous extent." He added that the work of construction would be done by a French firm, and that he had already received applications for concessions of power. He said soundings were going on at the present time at the mouth of the Rance with a view to starting work on the reservoirs.

The most difficult task of the French engineers was to perfect a turbine which would work reliably under water and which would turn with great quickness in response to a comparatively slow movement. It is understood that the most important part of the construction will consist of three reservoirs formed by walls 500 yd. long and 25 yd. high, measured from the bed of the river. The Minister said that he expected the Rance plant to develop 30,000 hp. or 40,000 hp.—*Electrical World.*

Photo by Ewing Galloway, N. Y.

Michigan Central Yards at Detroit

Electric Traction in Foreign Countries

RAILROAD conditions in European countries as seen by an electric traction expert were outlined by F. H. Shepard, director of heavy traction, Westinghouse Electric & Manufacturing Company, at the April meeting of the New York Railroad Club. Mr. Shepard has just returned from an eleven-weeks' trip through the more important European countries and he outlined his impressions as follows:

The high rate of exchange makes railroad development a difficult problem in almost all foreign countries. Efficiency of labor has fallen off and government operation has caused many undesirable conditions to arise. In addition a jealousy between some of the new countries has complicated the situation.

Traffic in England has fallen off to almost the same extent as it has in the United States. The equipment is in fair condition. In Sweden it was learned that a trip into Russia was a possibility but was extremely dangerous. Russia is in dire circumstances because of lack of transportation. The absence of paint and lack of finish is particularly noticeable in Germany. Many employees are required for a comparatively small amount of work and some women are still employed in train service. Traffic movement is probably not more than 50 per cent of normal. The various electric plants are, however, in better general condition than the railroads and throughout most of the country there is evidence of a serious intent to get production started. Switzerland has suffered from the general depression, but is well off insofar as equipment is concerned. The depression has also had its effect in Italy and the situation has been complicated by strikes caused by Bolshevist propaganda. In France the railroads in the devastated regions have been fairly well restored. Business is slow in Belgium, but there are indications that there will soon be a resumption. Railroad equipment is in very fair condition. Holland has been doing a large amount of business.

The high cost of fuel and the difficulty of obtaining it have affected the railroads of most European countries and have made electric operation particularly desirable. Furthermore, each country is now more than ever desirous of being self-contained insofar as industry and transportations are concerned. The result of these conditions is an electrification program which is outlined roughly in this table:

RAILROAD ELECTRIFICATION (ROUTE MILES)

	In operation	Under construction	Proposed
Sweden	300	125	1,000
Norway	60	50	500
Germany	400	100	1,500
Austria	200	...	1,000
Switzerland	250	275	1,000
Italy	600	...	3,000
France	50	...	5,000
England	200	...	1,000
Holland	50	...	600
Belgium	...	...	500

A Train of 60 Refrigerator Cars on the New York Central

New Steel Coaches for the Erie Railroad

Car Wiring Reduced to the Simplest Possible Construction and All Conductors Fully Protected by Conduit

THE Erie Railroad is adding a number of new steel cars to its equipment for use in suburban service operating out of Jersey City. Forty-eight of these cars were ordered from the Standard Steel Car Company, Hammond, Ind. The order called for 42 steel suburban coaches and six steel combination passenger and mail cars. At the present rate of delivery, the entire lot will soon be in operation. The new coaches are not quite

Interior View of One of the New Cars

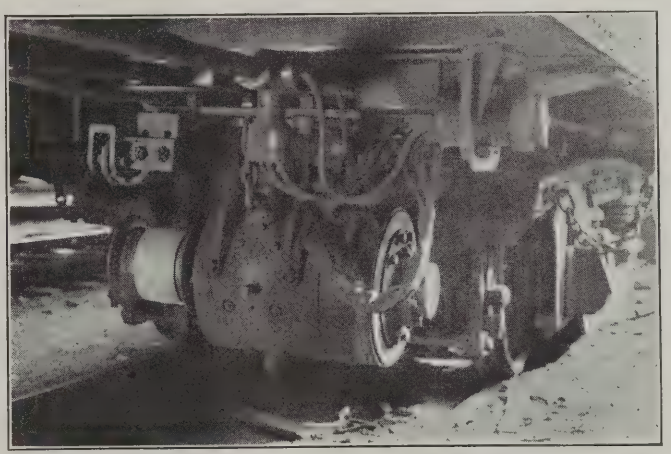
as heavy as the Stillwell type of car which the Erie adopted some time ago and, unlike the Stillwell cars, the trucks are formed of pressed steel. Four wheel equalized trucks with clasp brakes are used. The new coaches are practically the same length as the older ones but have a seating capacity of 82 persons which is two less than the Stillwell coach owing to the addition of a second toilet. The seats are upholstered with black imitation leather.

Lighting Facilities

The lighting facilities of the new cars consist of the regular Safety Car Heating & Lighting Company's 2 kilowatt equipment supplemented by a set of Edison cells. The general illumination of the car is furnished by 11 lamps mounted along the center line of the car at 5½-ft. centers. The lighting arrangement used consists of type C nitrogen 40-watt P. S. 20 bulbs supported in 19030 Safety fixtures using a 18246 satin finish Holophane shade. A light gray head lining is used which aids materially in the distribution of light. Each toilet is equipped with one 25-watt lamp and the platforms have two 25-watt lamps each. The latter are mounted flush with the car ceiling directly over each set of steps. Polished aluminum reflectors are used with the platform lights.

The switchboard which is mounted in a separate locker directly above the generator and lamp regulator panel is the Safety company's type C. From this switchboard three circuits control the lighting of the car through three double pole single throw knife switches. The lamps along the center of the car are connected alternately to two of these switches, one switch controlling five of the lamps and the other, six. The lamps in the toilet and on the platforms are controlled by the third switch. A fourth switch is used to connect the train lighting line to the equipment on the car whenever emergency conditions arise which make such a connection necessary.

The trouble which has been experienced in the loss of so many train line connectors in the past, particularly on suburban cars, has been practically eliminated by keeping two train line jumpers under lock on each car. One of these jumpers is kept in the trainman's locker and the other in the electrician's locker. The trainmen do not have access to the electrician's locker, nor can the electricians open the trainmen's locker. A man from the car lighting department, however, is on hand whenever a train is about to leave the station, to inspect the trainmen's locker in the presence of the trainman himself for



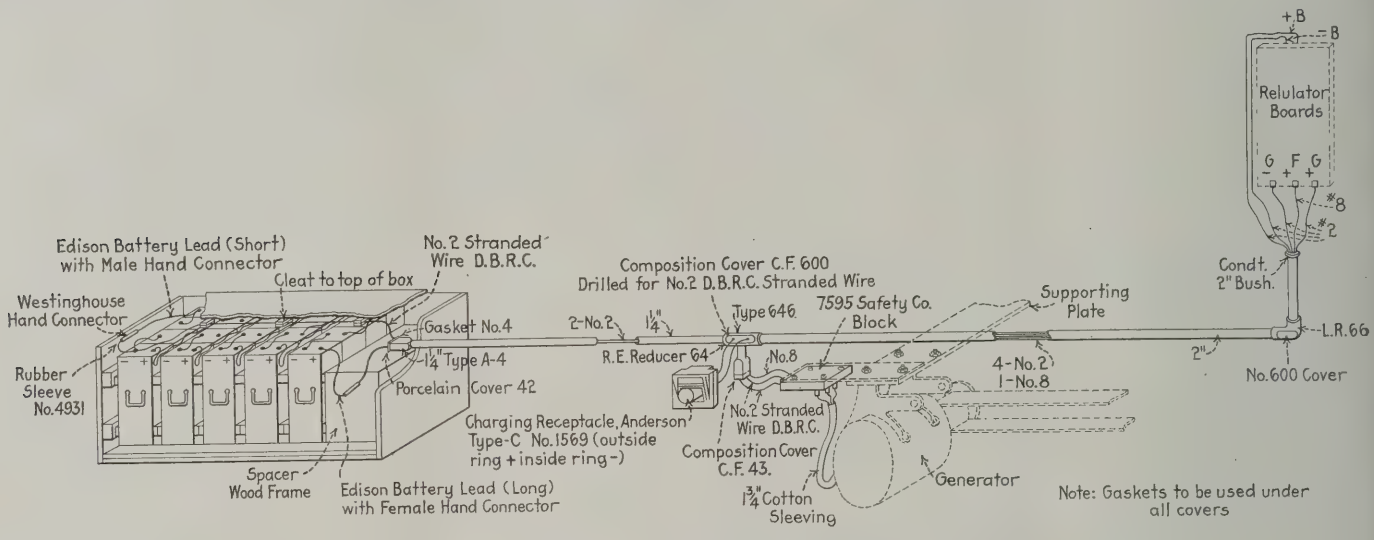
Arrangement of Conduit Fitting and Wiring Devices With Respect to the Generator Location

the purpose of ascertaining whether or not the train line connector is in its proper place. This method of inspection has been the means of saving many jumpers for it narrows the responsibility for their safe keeping.

Conduit and Wiring

The wiring on the car is carried entirely in conduit. From the switchboard panel six wires controlling the car lighting circuits extend in a single conduit to a point between the ceiling and the roof of the car just outside the car door. From this point branches of conduit extend to the nearby platform lights and toilet light, while the

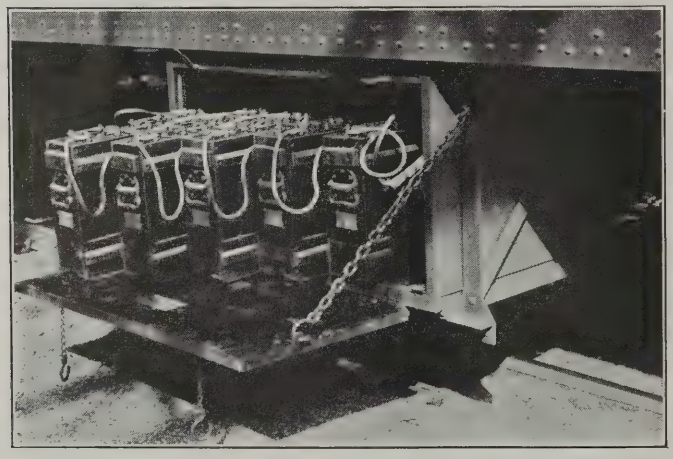
main run extends down the length of the car to a similar box at the far end. The outlet boxes which are mounted in the main run of conduit are of special construction in order to furnish suitable support for the lighting fixtures which are attached to them. The train lighting line which consists of two No. 2 B. & S. stranded conductors and which extends between connection boxes leads are tapped at this "T" fitting and the two tap wires are brought out through two holes drilled in a composite insulation cover plate attached to the side of the "T." The two tap wires are connected to an Anderson type C charging receptacle located close to the terminal block and generator. The main battery leads continue on to the battery box to the top of which they are secured with



Detail Diagram Showing Type of Equipment Used and Method of Installation

at either end of the car, is tapped at a point above the head lining near the switchboard and the taps brought down to the switch in the switchboard locker.

From the regulator panel locker in the car to a point directly over the generator, five wires are run in 1½-in. conduit. Four of these wires are No. 2 B. & S. and the fifth which is a part of the generator field circuit is a No. 8 B. & S. conductor. All conductors are stranded. Two of the larger wires are the positive and negative leads from the generator. These two leads together with the No. 8 field circuit wire leave the conduit through an



Type of Battery Box Used. The Chain Shown is Removed and Placed Within the Box When the Door Is Closed

"A" condulet screwed into a Crouse-Hinds "T" which is located immediately above the generator. The three wires terminate in a Safety terminal block from which point their respective circuits are continued to the generator by short jumper wires protected by canvas sleeving.

The remaining two wires which are the main battery split porcelain cleats, their ends terminating on the positive and negative poles of the battery. At all points where the wiring is brought out of the conduit to any equipment, the connections are so made that the positive wires will always be on the right hand side.

The Edison type of battery has been adopted as standard on the Erie and the battery equipment of each car consists of 25 cells type A-6-H having a capacity of 225 ampere-hours. It has been estimated that a battery of this capacity will give satisfactory service on trains operating on short suburban runs, which represent the most difficult of car lighting conditions.

The boxes for housing the battery equipments are somewhat smaller than those used with lead cells. The inside length of the box is 45 in., the height, 22½ in., and the depth, 28 in. These boxes are of such size as to accommodate eight lead storage cells and if it should be desired at some future time to use lead cells, the only change necessary would be to install a second box of the same size on the opposite side of the car.

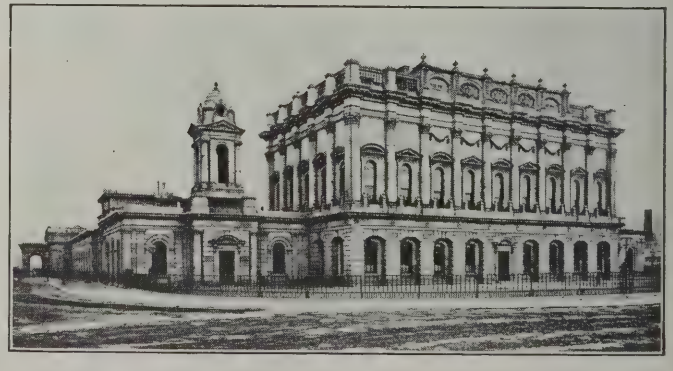


Photo by Keystone View Co.

Kings Bridge Station at Dublin, Ireland, Scene of Numerous Riots

Effect of Heat Treatment on Metal Arc Welds*

Ring Specimens Used for Testing Permit the Taking of Many Samples from Small Welded Section

By James W. Owens, J. H. Ramage and J. A. Watts
U. S. Navy Yard, Norfolk, Va.

AMONG other metallographic features peculiar to all metal arc welds of iron and steel, made in air, the needle-like lines observed in the micro-photograph, Fig. 1, are perhaps the most outstanding and distinctive.

Considerable discussion has taken place and difference of opinion exists as to the composition and cause of these needles. They have been called strain lines, twining lines, martenside, carbide and nitride by various investigators, but it is now almost unanimously agreed that the needles are an indication of the presence of nitrogen in the metal, probably in the form of iron nitride.

Similar lines have been found in pure iron which had been nitrogenized by heating in an atmosphere of ammonia gas, by Strauss, Ruder and others. These investigators also found several other forms of nitride which they attribute to varying amounts of nitrogen.

Experimental work by the authors at the Norfolk Navy Yard indicates that the heat treatment to which the deposited metal has been subjected determines the form of the nitride in the metal, and that the form in which the nitride exists has a very decided effect upon the

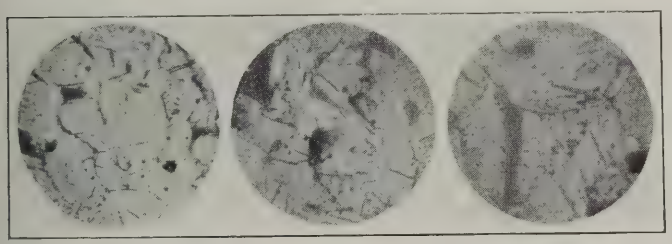


Fig. 1 Fig. 2A Fig. 2B

Fig. 1—Normal Amount of Oxygen and Nitrogen (X225)
Fig. 2A—Large Amount of Oxygen and Nitrogen Produced by Long Arc Showing Nitride Eutectic (X225)
Fig. 2B—Showing an Extra Large Nitride Needle (X1050)

physical properties of the metal. The presence of nitride, as well as the exceptionally large amount of oxide found in the deposited metal, may be explained as follows:

The electrode material, in passing through the arc, either in the molten or vaporous state, encounters an atmosphere of nascent oxygen and nitrogen formed in the arc by the breaking down of the molecular structure of these constituents of the air.

Nitrogen, although ordinarily very inactive, is, at this high temperature and in the nascent or mon-atomic state, very active, and immediately combines with the iron. The longer the air gap through which the metal passes, the greater will be the nitrogen content in the deposit. This is evidenced by the greater number of needles and pearlitic-like nitride found in welds made with a long arc, as well as the weakness of these welds, Figs. 2A and 2B. If it were possible to entirely exclude the air from the metal in the arc during the welding operation, the ductility of the deposit would be greatly increased.

When made with a mild steel or ingot iron electrode, the deposit is almost carbonless iron. Iron in its pure state would be very ductile and fairly strong, but in the weld is comparatively weak and very brittle, owing to its strained, large and columnar grain structure, Fig. 3, and large content of oxide and nitride of iron, besides slag inclusions and blow holes, Fig. 1.

In our investigations welds were made under varying conditions, and subjected to a variety of cooling treat-

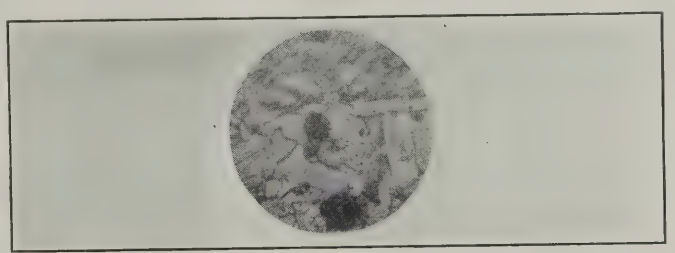


Fig. 3—Columnar Grain Structure Produced By Chilling (X900)

ments. Upon examining some very rapidly chilled welds, no needle-like structure at all was apparent, although made from the same electrode material and in the same manner as other welds, except for this chilling, etc. This indicated either that there was no nitrogen in these welds or that it was present dissolved in the ferrite. This suggested a line of research, the results of which follow.

Effect of Heat Treatment Upon Nitride in Welds

A bar made entirely of deposited material was prepared, from which seven test rings were cut and numbered consecutively 1 to 7. Rings Nos. 3, 4, 5 and 6 were heated

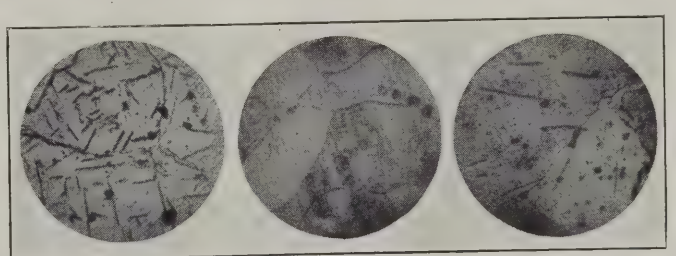


Fig. 4 Fig. 5 Fig. 6

Fig. 4—After Annealing. Showing Needles and Oxide Spots as in Fig. 1, But Pearlitic—like Areas Have Disappeared (X900)
Fig. 5—After Quenching. Showing Structure Similar to Pure Metal. Needles Have Disappeared But Oxide Spots Still Present (X900)
Fig. 6—Specimen (Fig. 5) Re-heated to 2000° F. and Cooled in Furnace. Needles Re-appear But Fewer in Number (X1050)

to 2,250 deg. F. for about three hours. Nos. 3 and 4 were allowed to cool in furnace, while Nos. 5 and 6 were removed and quenched in ice water. The structure of the metal as deposited, after annealing and after quenching is shown in Figs. 1, 4 and 5, respectively.

*Paper presented before the Metropolitan Section of the American Welding Society, New York.

As deposited, the metal shows the characteristic features of metal arc welds, namely, oxide spots, nitride needles and pearlitic-like nitride.

After annealing the metal had the same features as the ordinary deposited metal, showing needles and oxide spots, but the pearlitic-like areas had disappeared.

After violent quenching the structure is seen to be very

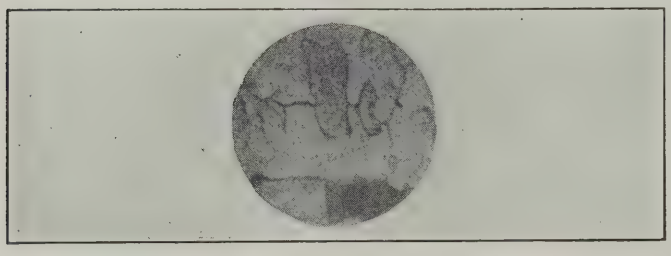


Fig. 7—Quenched at 950° F. Showing Nitrides Dissolved in Ferrite Causing Critical Point Also Curly Grain Structure and Darkening of Some of the Grains to a Brownish Shade (X1050)

much different from either the material as deposited or after annealing. The oxide spots were still present, but aside from these, the only other features were the grain boundaries, just as in pure metal and solid solutions.

The rings were now turned to the correct size for tensile and ductility tests in the Owens testing apparatus. The chips from rings 1 to 6, inclusive, were sent to the Bureau of Standards for determination of the nitrogen present as nitride.

The data collected on the physical properties of these rings is given in Table I.

It appeared from a study of the micro-structure and the data obtained that at some temperature between atmospheric and 2,250 deg. F. the nitrides are dissolved in the ferrite just as the carbides are, and that in this condition of solid solution the nitrogen renders the iron extremely brittle, without, however, affecting its hardness. The nitrogen, at least that present as nitride, is also reduced in amount by subjecting the metal to long heating at some temperature below 2,250 deg. F. Upon slow cooling through this new critical range the needles are again ultimately formed, but are fewer in number, due to the loss of nitride, and the metal regains some ductility. The carbon present was less than .05 per cent as determined by repeatedly checked analyses, and would not account entirely for the pearlitic-like areas which are assumed to be another form of the nitride, possibly together with some carbide.

No conclusion as to the strength of the deposited metal can be reached from the foregoing and no fair comparison can be made of strength and ductility before and after annealing, as the metal was soaked for a long time, as noted, at a temperature far above its recrystallization point, causing tremendous grain growth, as shown in micro-photograph, Fig. 4, and hardness tests.

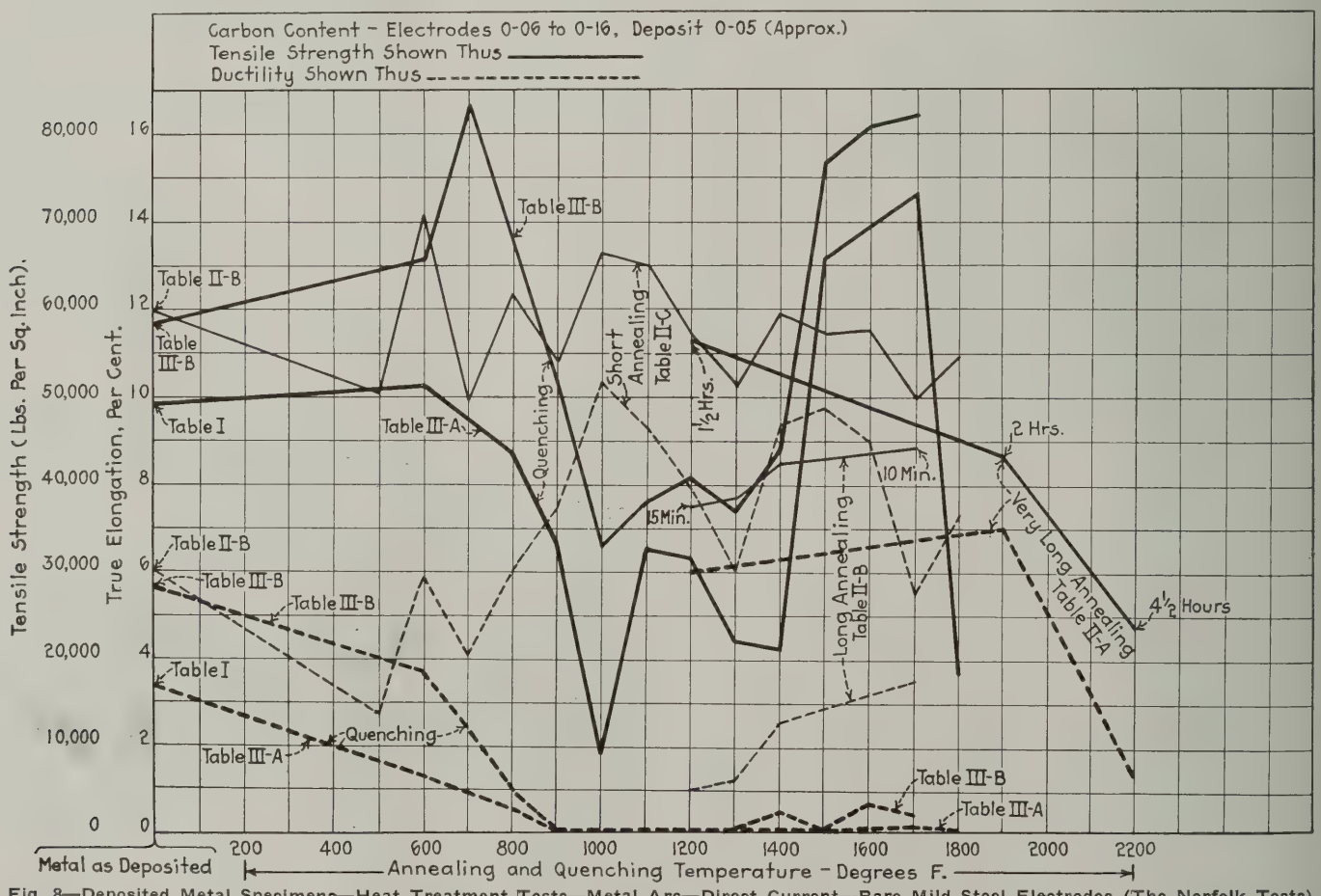


Fig. 8—Deposited Metal Specimens—Heat Treatment Tests—Metal Arc—Direct Current—Bare Mild Steel Electrodes (The Norfolk Tests). Curves Plotted From Data—Tables I, II A, B, C and III A, B

Ring No. 7 was now heated for a short time (approximately 15 min.) at 1,200 deg. F., and allowed to cool with the furnace, with results as noted, in Table I.

These results have been repeatedly checked since and always show that slow cooling from the proper temperature increases the ductility of the deposited metal. This

TABLE I

EFFECT OF NITRIDE ON TENSILE STRENGTH, DUCTILITY AND HARDNESS

Specimen number	Treatment	Ultimate strength: In lbs.	Ultimate strength: In lbs. per sq. in.	Elongation: In inches (circumferential)	Elongation: In per cent (of 3½ in.)	Per cent nitrogen as nitride	Scleroscopic hardness: Each specimen	Scleroscopic hardness: Average	Remarks*
1	As deposited	3,990	46,500	0.075	3.	0.142	21.6	...	
2	As deposited	4,450	52,000	0.090	3.75	0.141	22.2	21.9	
5	Heated to 2,250° F. for 3 hours, and quenched in ice water	1,800	19,500	0.030	1.25	0.041	14.0	15.1	
4	Heated to 2,250° F. for 3 hours, and allowed to cool in furnace	1,950	20,000	0.035	1.50	0.038	16.2	...	
5	Heated to 2,250° F. for 3 hours, and quenched in ice water	1,570	16,000	0.000	.0	0.051	18.0	19.0	
6	Heated to 2,250° F. for 3 hours, and quenched in ice water	1,880	19,000	0.000	.0	0.048	20.0	...	
7	Heated to 1,200° F. for 15 minutes, and allowed to cool in furnace	4,570	54,000	0.210	8.75	....	...	...	

Each layer of deposit cleaned with brush only.

would indicate that the rate of cooling of the weld in air as occurs in ordinary practice is too rapid to permit all of the embrittling dissolved nitride coming out of solution.

The quenched samples, showing no needles, Fig. 5, were reheated to about 2,000 deg. F., and slowly cooled for further proof that the nitride was still in them, Fig. 6. This micro-photograph is typical of the structure of these specimens, which again show the needle structure, the needles, however, being fewer in number.

An attempt was made to determine the critical points with a transformation point recorder, but only two very faint points were found in all samples at approximately 1,400 deg. F. and 1,580 deg. F., both undoubtedly iron

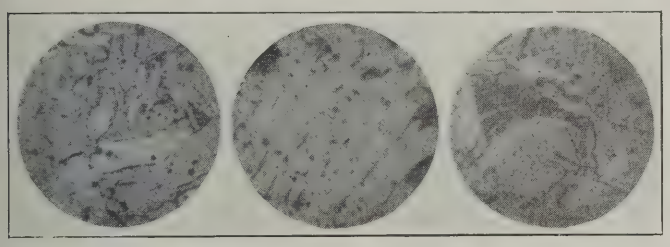


Fig. 9 Fig. A Fig. B

Fig. 9—Quenched at 850° F. Needles Begin to Form (X1050)
Fig. 9A—Quenched at 775° F. Pearlitic and Needle-like Form (X1050)
Fig. 9B—Quenched at 775° F. Pearlitic-like Form at Higher Magnification (X1200)

or very low steel points. No attempts were made to carry the cooling below 1,000 deg. F.

Determination of Temperature at Which Nitride Changes Take Place and Corresponding Structural Changes

In order to determine by microscopic examination and physical tests where this change in nitride and ductility took place a large number of rings of deposited material were prepared. The carbon content of this material was below .06 per cent and the rings were subjected to various heat treatments, photographed and tested. The results of these tests are tabulated in Tables II-A, II-B, III-A, and III-B.

An average tensile strength and ductility of rings as deposited is 58,166 lb. per square inch, with 5¾ per cent elongation in 3½ inches, Table III-B.

While the few tests run in the short period devoted to this work are not sufficient to establish beyond doubt all of the phenomena of the nitride changes in iron, the following conclusions seem to be well founded:

At some temperature between 800 and 1,000 degrees Fahrenheit, the nitrogen in the iron as iron-nitride is dissolved in the ferrite, Fig. 7, giving rise to a critical point. The ferrite containing dissolved nitrides is rendered very

TABLE II

EFFECT OF ANNEALING ON TENSILE STRENGTH AND DUCTILITY

Remarks—(a) Temperature of furnace was gradually reduced and each specimen put in at temperature given, and maintained at this temperature for time specified. (b) A specimen or specimens once put in, remained in furnace until cold.

A—Very long annealing (each layer cleaned with brush only)

Specimen number	Temperature in degrees F.	Time specimen was held at temperature specified	Ultimate strength: In lbs.	Ultimate strength: In lbs. per sq. in.	Elongation: In inches (circumferential)	Elongation: In per cent of 3½ in. (true)
5a	2,250	4½ hrs.	1,880	19,000	.030	1.25
6a	2,250	4½ hrs.	1,950	20,000	.035	1.50
H20	1,900	2 hrs.	3,360	38,500	.221	9.25
H27	1,900	2 hrs.	3,510	40,500	.245	10.25
7a	1,200	1½ hrs.	4,575	53,750	.210	8.75

B—Long annealing (each layer cleaned with brush only)

19	1,700	10 min.	3,640	42,000	.125	4.75
16	1,400	15 min.	3,470	40,000	.085	3.50
17	1,300	15 min.	3,110	36,000	.045	1.75
18	1,200	15 min.	3,100	36,000	.040	1.50

C—Short annealing (each layer of deposit cleaned with brush)

Remarks—(a) Specimens specially deposited for test given. (b) Three separate tests, A, B, C. (c) Averages used for plotting curves.

Specimen number	Test number	Annealing temperature in degrees F.	Ultimate strength: In lbs.	Ultimate strength: In lbs. per sq. in.	Elongation: In inches (circumferential)	Elongation: In per cent of 3½ in. (true)
1–a.....	1	1,800	4,860	57,000	0.275	11.5
1–b.....	2	1,800	Poor specimen		....	....
1–c.....	3	1,800	4,430	52,000	.12	5.0
Average..	..	....	4,645	54,500	.197	8.2
2–a.....	1	1,700	3,890	45,000	.098	4.0
2–b.....	2	1,700	Poor specimen		....	....
2–c.....	3	1,700	4,750	56,000	.17	7.0
Average..	..	....	4,320	50,500	.134	5.5
3–a.....	1	1,600	4,860	57,000	.175	7.0
3–b.....	2	1,600	4,070	47,500	.16	6.75
3–c.....	3	1,600	5,930	67,500	.32	13.25
Average..	..	....	4,950	57,650	.218	9.0
4–a.....	1	1,500	5,060	59,500	.180	7.5
4–b.....	2	1,500	4,220	49,500	.1	4.0
4–c.....	3	1,500	5,460	63,000	.30	12.5
Average..	..	....	5,800	57,300	.193	8.0
5–a.....	1	1,400	4,160	48,500	.130	5.5
5–b.....	2	1,400	5,010	59,000	.22	9.25
5–c.....	3	1,400	6,330	71,200	.33	13.25
Average..	..	....	5,160	59,560	.226	9.33
6–a.....	1	1,300	4,270	47,740	.07	2.73
6–b.....	2	1,300	4,020	47,000	.065	2.75
6–c.....	3	1,300	6,200	70,000	.31	13.0
Average..	..	....	4,830	54,900	.148	6.16
7–a.....	1	1,200	5,380	62,500	.11	4.5
7–b.....	2	1,200	4,160	40,750	.17	7.0
7–c.....	3	1,200	5,070	59,750	.30	12.5
Average..	..	....	4,870	57,000	.193	8.0
8–a.....	1	1,100	6,530	73,000	.22	9.25
8–b.....	2	1,100	5,350	62,500	.195	8.0
8–c.....	3	1,100	5,070	59,750	.26	10.75
Average..	..	....	5,650	65,080	.225	9.33
9–a.....	1	1,000	5,680	65,000	.13	5.5
9–b.....	2	1,000	Poor specimen		....	....
9–c.....	3	1,000	6,080	68,750	.36	15.0
Average..	..	....	5,880	66,875	.245	10.25
10–a.....	1	900	4,230	49,500	.055	2.25
10–b.....	2	900	4,580	53,750	.2	8.25
10–c.....	3	900	5,010	59,000	.28	11.75
Average..	..	....	4,676	54,080	.34	7.41
11–a.....	1	800	7,230	78,000	.15	6.25
11–b.....	2	800	4,070	47,750	.076	3.0
11–c.....	3	800	5,010	59,000	.21	8.75
Average..	..	....	5,436	61,910	.145	6.0
12–a.....	1	700	3,835	44,500	.01	0.25
12–b.....	2	700	4,830	57,000	.12	5.0
12–c.....	3	700	4,930	58,250	.19	8.0
Average..	..	....	4,531	49,910	.106	4.5
13–a.....	1	600	6,770	74,500	.11	4.5
13–b.....	2	600	4,640	70,625	.105	4.25
13–c.....	3	600	5,850	66,750	.215	9.0
Average..	..	....	6,198	62,250	.146	6.00
14–a.....	1	500	4,450	52,000	.038	1.5
14–b.....	2	500	4,200	49,000	.051	2.0
14–c.....	3	500	4,260	50,000	.09	3.75
Average..	..	....	4,303	50,300	.327	2.75
			Material as deposited			
15–a.....	1	....	5,458	54,000	.062	2.5
15–b.....	2	....	5,370	62,000	.150	6.25
15–c.....	3	....	5,400	62,500	.22	9.25
Average..	..	....	....	59,500	....	6.0

brittle, losing practically all of its ductility. This is clearly shown in curves, Fig. 8. With slow cooling back through this range, the nitride comes out of solution and ultimately assumes either the needle-like form, Figs. 1 and 4, or the pearlitic-like form, Fig. 9B. It is yet undetermined which is the ultimate state of equilibrium at low temperature. With the nitride no longer in solid solution, the ferrite regains its ductility. The transition

TABLE III

EFFECT OF QUENCHING ON TENSILE STRENGTH AND DUCTILITY

Remarks—(a) Specimens heated to temperature given and quenched in ice water at temperature specified. (b) Specimens "A" quenched at a lower temperature than that to which heated, while specimens "B" were quenched at the same temperature to which heated.

Specimen number	Time in furnace	Temperature in degrees F. to which heated	Quenching temperature in degrees F.	Ultimate strength: In lbs.	Ultimate strength: In lbs. per sq. in.	Elongation: In inches (circumferential)	Elongation: In per cent of 3½ in. (true)
A—Each layer of deposit cleaned with brush only							
A–4	4½ hrs.	2,250	2,250	1,740	18,390	.000	.000
B–4	2 hrs.	1,900	1,800	1,070	10,540	.000	.000
B–20	2 hrs.	1,900	1,700	6,140	73,253	.007	.020
B–14	2 hrs.	1,900	1,500	5,380	65,875	.004	.011
4	15 min.	1,900	1,400	1,020	21,080	.000	.000
5	15 min.	1,300	1,300	2,000	22,134	.0005	.001
6	15 min.	1,200	1,200	2,680	31,620	.002	.005
F	15 min.	1,100	1,100	2,010	32,674	.000	.000
E	15 min.	1,000	1,000	1,000	9,486	.000	.000
D	15 min.	900	900	2,780	33,201	.003	.008
C	15 min.	800	800	3,570	43,741	.020	.57
A	15 min.	600	600	4,170	51,119	.065	1.85
B—Each layer of deposit cleaned with pneumatic roughing tool							
A	5 min.	1,700	1,700	7,790	82,000	.014	.5
B	5 min.	1,600	1,600	7,710	81,000	.018	.75
C	5 min.	1,500	1,500	7,000	76,250	.000	.0
D	5 min.	1,400	1,400	3,780	44,000	.015	.5
E	5 min.	1,300	1,300	3,200	37,000	.001	.0
F	5 min.	1,200	1,200	3,500	40,500	.000	.0
G	5 min.	1,100	1,100	3,330	38,250	.000	.0
H	5 min.	1,000	1,000	2,910	33,000	.000	.0
I	5 min.	900	900	4,460	52,000	.000	.0
J	5 min.	800	800	5,920	67,500	.025	1.0
K	5 min.	700	700	7,910	82,750	.062	2.5
L	5 min.	600	600	5,720	65,500	.09	3.75
Material as deposited							
1	.....	....	....	5,090	60,000	.145	6.0
2	.....	....	....	5,140	60,500	.178	7.5
3	.....	....	....	4,600	54,000	.092	3.75
Average	.....	....	....	....	58,166	...	5.75

is not rapid, requiring quite a long period of time at or near this range.

The nitride seems to cause several structural changes in the metal during the transition, first a sort of a curly grain structure, Fig. 7, then a darkening of some of the grains to a brownish shade, shown in the same figure, then possibly a coagulation of the nitride in the pearlitic-like areas, Figs. 9A and 9B, and finally the needles, assuming that the needles are the ultimate form. The needles appear to have no effect upon the ductility or strength of the ferrite, acting merely as a mechanical inclusion. Mr. S. W. Miller mentions this in his paper on "The Path of Rupture in Steel Fusion Welds."* The metal also appears to drop off considerably in tensile strength during the transition stage, again regaining it after completion of the solid solution.

The ultimate strength curves of the quench specimens, Fig. 8, also clearly shows the effect of the recrystallization point in the vicinity of 1,500 to 1,700 deg. F., indicating that this new critical range is entirely distinct from that in which the recrystallization and carbon changes take place, as also do the critical points found and previously mentioned.

The foregoing indicates that the nitride, although a very important source of brittleness, may be reduced by slow cooling from above 1,000 deg. F. There will always, however, exist an extremely weak and brittle point at or near 1,000 deg. F. and metal arc welds cannot, with

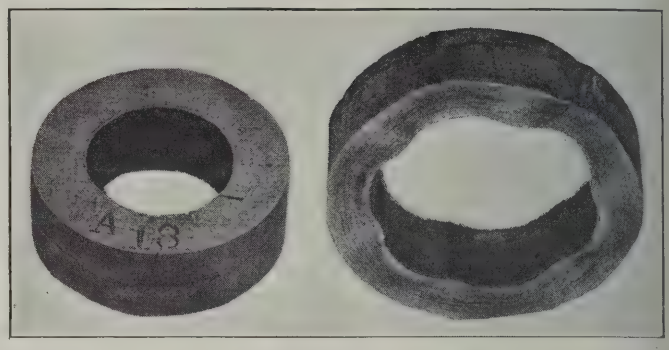


Fig. 10A Fig. 10B

Fig. 10A—Standard Specimen

Fig. 10B—Base Metal (Ship Plate) Specimen After Test. The Specimens Are Tested by Using an Ordinary Testing Machine to Force a Hardened Steel Wedge Into a Split Ring Placed Inside the Specimen

safety, be subjected to stresses when near this temperature until a method of preventing nitrogenization and oxidation during welding is developed.

The curves, Fig. 8, show the effect of short, long and

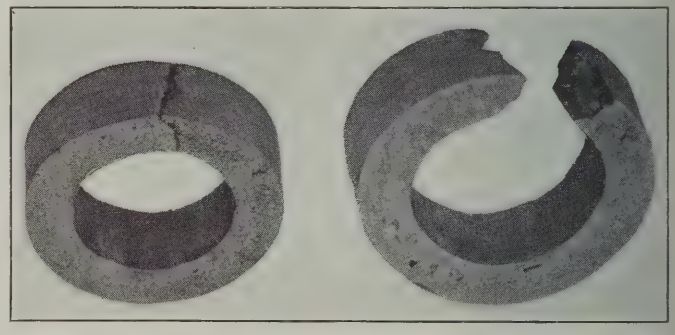


Fig. 10C Fig. 10D

Fig. 10C—Showing Fracture Deposited Metal Bare Mild Steel Electrode Used Specimen After Test

Fig. 10D—Same as Fig. 10C Expanded to Showing Structure

very long annealing, also quenching and metal as deposited.

It is proposed to check up these results by further research.

Fig. 10 shows test specimens used in the test. Note the difference in ductility between the base and deposited metal specimens.

Discussion

Written discussions of the paper were submitted to the American Welding Society. S. W. Miller, Rochester Welding Works, Rochester, N. Y., submitted a discussion in which he stated that, in his opinion, not enough tests had been made to warrant the conclusions drawn. He also suggested that the method of testing used was admirably suited for checking up welders, but not desirable for obtaining exact values of tensile strength and elongation. In connection with the discussion of the strength of electric arc welds made with bare mild steel electrodes, Mr. Miller said, "It should not be forgotten that as yet there is no proof that the so-called needles are

* *Presented before the American Institute of Mining Engineers, New York, February, 1919.*

nitride of iron, or that the eutectoid, which has the appearance of pearlite, is really composed of iron nitride, because as yet the chemical compositions of these items have not been determined. In spite of this, I believe that the needles and eutectoid are really caused by the presence of nitrogen. The facts are that the structure of arc welds resembles iron that has been subjected to the action of ammonia at high temperature."

Henry F. Rawdon, physicist, Bureau of Standards, elaborated on and explained some of the results obtained by Mr. Owens by means of data which had been gathered by the Bureau of Standards.

In answer to Mr. Miller's criticism of the accuracy of the method of testing employed, Mr. Owens stated that the method of testing had been greatly improved. Originally, a tapered conical plug was inserted in the cylindrical hole of the ring and no allowance made for variable friction. Now, the ring shaped specimen is placed on a hardened steel die which rests on the base of a standard testing machine and is expanded to the point of fracture of the specimen by a hexagon shaped plug, which bears against a hexagon wedge divided into sectors which is inserted in the hole of the ring. The surfaces of both plug and wedge are carefully hardened and ground to secure a constant coefficient of friction. The load required to break the ring is noted on the testing machine and the true breaking strength calculated, proper allowances being made for friction. The per cent elongation is obtained by measuring the circumferential stretch of the ring by a suitably designed gage. Calibration curves for both friction and per cent elongation are used, the accuracy of which have been verified by checking against standard tensile specimens.

The discussion presented by Mr. Ramage dealt with Mr. Miller's reference to the identity, or lack of identity, of the needles. Mr. Ramage said, "No attempt was made by the author to prove that the needles are iron nitride, but it was simply stated that it is now almost unanimously agreed that the needles are an indication of the presence of nitrogen in the metal, probably in the form of iron nitride. The needles are called nitride throughout the paper simply as a means of identification. However, aside from this point, no evidence was presented to prove them other than nitride."

Mr. Watts stated that metal arc welds, due to their varying rate of cooling, may contain some of the nitrogen in solid solution and some in the visible form, such as needles and plates, thus imparting varying degrees of brittleness to the deposited metal.

Electrical Progress in Japan

THE latest annual report from the department of railways, Government of Japan, gives some interesting facts regarding the extent to which electricity is being applied to railroad use in that country.

The electrical equipment in use may be summarized as follows: Six hundred miles of power cable, having a wire length of 2,140 miles; 183 miles of third rail; 76 prime movers developing 25,682 hp.; 98 generators and convertors, representing 25,083 kw. and 204 transformers representing 17,323 kw. The motor stock comprises 748 motors (10,889 hp.) for power supply purposes, 522 motors (36,634 hp.) for the operation of 152 electric trains and 24 motors (7,920 hp.) for 12 electric locomotives. The electric lighting apparatus consists of 83,921 incandescent lamps, requiring 3,309 kw., 54 arc lamps requiring 37 kw., besides 33,838 incandescent lamps fitted in coaches. The power supply from the power stations totaled 33,584,-864 kw. hr., and the transformer stations supplied 27,968,-709 kw. hr.

Electric Power Stations and Sub-Stations

On March 31, 1918, there were 16 power stations and 24 sub-stations in operation. Compared with the preceding year, the power stations showed no increase in number, while the sub-stations increased four. The distribution of these plants was as follows:

Power Stations.—Main Island: Yokogawa, Omiya, Sandaigawa, Yaguchi, Kashiwagi, Hamantsu, Osaka, Takatroi, Okayama, Shimonseki.

Island of Hokkaido: Kuromatsunai, Muroran, Oiwake, Asahigawa, Ikeda, Shimofurano.

Sub-Stations.—Main Island: Maruyama, Yagasaki, Tsuchizaki, Nagano, Ikebukuro, Harajuku, Eirakucho, Oimachi, Kawasaki, Oi Works, Nagoya, Kanazawa, Minatomachi, Kyoto, Kobe, Himeji, Hiroshima.

Island of Kyushu: Kokura, Moji, Tobata, Nagasaki, Wakamatsu, Wakamatsu Works.

Island of Hokkaido: Naebo.

The Shimofurano power station was newly established in April, 1917. In June the Naebo power station was converted into a sub-station, and in August and September three sub-stations were newly provided at Nagasaki, Oi Works and Wakamatsu Works.

Compared with the preceding year, the prime movers decreased eight, representing 1,773 hp., and the dynamos and convertors also decreased seven, representing 1,022 kw., while the transformers increased 19, representing 763 kw.

The financial results of the year's operation were as follows:

Power Stations	
Total current supply	33,584,864 kw. hr.
Total operating expenses	$378,705
By-product earnings	$106,957
Net expenses	$271,748
Average net expenses per kw. hr	.81c

Sub-Stations	
Total current supply	27,968,709 kw. hr.
Total operating expenses	$283,558
By-product earnings	$6,385
Net expenses	$227,174
Average net expenses per kw. hr	.991c

Power Transmission Lines

In addition to the length of power transmission lines, mentioned in the second paragraph of this article, there are also 48.8 trolley lines with a total wire length of 156 miles, 185 miles of rails being used for return circuits. Compared with the preceding year, the length of transmission lines increased 78 miles, or 16.5 per cent, and the length of wire 190 miles, or 10.6 per cent, while the trolley lines increased only 2.4 miles with 7.3 miles of wire length.

Electric Lamp Stock and Motors

Compared with the preceding year, the number of incandescent lamps increased 8,366, or 11.7 per cent, and the watts represented thereby showed an increase of 22 kw., or 7 per cent, while the arc lamps decreased 11, or 16.92 per cent, representing 8 kw., or 17.23 per cent.

The motors in service represent an increase of 59, or

8.56 per cent over the preceding year, but with a decrease in capacity of 63 hp., which is represented by a decrease of .58 per cent.

Train Lighting

At the end of March, 1918, there were 20 train electric lighting houses located generally at the termini or junctions of the leading lines. The passenger coaches lighted by electricity totaled 3,834, and the number of lamps used for this purpose was 33,838. The number of generators used was 1,147, while 27,701 cells comprised the storage battery equipment. As compared with the preceding year, the passenger coaches increased 22, or .58 per cent, the lamps 440, or 1.32 per cent, the generators 16, or 1.41 per cent, and the battery cells 380, or 1.39 per cent.

The expenses of train lighting aggregated $222,908, working out to $75.41 per unit of equipment. Compared with the preceding year, the expenses increased $48,339 and the average per unit $15.41.

Electric Cars and Locomotives

The details of working of electric cars and locomotives during the year are as follows:

Electric Cars	
Mileage run	6,968,946.6
Car mileage reduced	6,598,090.5
Current consumed in kw. hr.	15,279,313
Value of current consumed in kw. hr.	$135,997.43
Current consumed in kw. hr. per 100 electric car miles	232
Value of current consumed in kw. hr. per 100 electric car miles	2.06
Electric Locomotives	
Mileage run	149,166.6
Vehicle mileage hauled	1,008,777
Current consumed in kw. hr.	2,979,693
Value of current consumed	$60,088.37
Current consumed in kw. hr. per 100 locomotives miles	1,998
Value of current consumed per 100 locomotive miles	40.28

Training of Railway Men

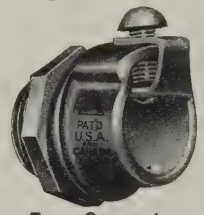
The Central Institute is provided for giving professional education to railway servants upon subjects bearing on railway business in general. It is divided into four departments—railway business, technical, electrical and English language course.

The technical course consists of such subjects as mechanics, steam and electric motive power, locomotives, passenger and freight cars, passenger and freight business, drawing, tracks and roadway, safety working, train-working, telephony and telegraphy, mathematics and the English language.

The electrical course, in addition to most of the above subjects, includes electricity and magnetism, motors and generators, electric lighting and power, electric railway, electric signals and an outline of rolling stock and motive power.

Box Connector for Flexible Conduit

The device shown in the illustration is a connector for metallic flexible conduit with an adjustable clamp. It is adaptable to a wide range of type and sizes of conduits and the advantages claimed for it are ease and rapidity of installation. A projection on the clamp and inside of the sleeve is designed to engage the groove of the BX conduit and prevent slipping. The set screw is located in the center of the sleeve. When pressure is applied with a screw driver, the position of the screw prevents the entire connector from loosening and turning in the outlet box. The end of the screw is upset to safeguard against loss. This clamp was brought out recently by the Nicholson Electric Fittings Company and all patents and machinery necessary for manufacture have been purchased by The Appleton Electric Company, Wellington avenue, Chicago.



Box Connector for B X Conduit

Photo by Ewing Galloway

Aerial View of Union Station, Senate Office Building and Post Office, Washington, D. C.

Characteristics of the Electric Locomotive*

A Discussion of Inherent Advantages Which Clearly Show to What Extent the Steam Locomotive is Outclassed

THE rapid growth of the United States in population and in wealth has been made possible only through its vast network of railways. Our railways and practically the entire inland transportation system have grown up around the steam locomotive. To this picturesque personification of power then, we owe our national greatness. However, there have been many evidences in the last few years which indicate that our railways need more power, and a different kind of power, than the steam locomotive can supply.

The rapid growth of the country, stimulated as it was by the railways, has imposed most severe requirements on them. There has been an unceasing demand from the traffic department for more power, for larger and still larger locomotives. The steam locomotive designers have risen to the occasion magnificently and the modern steam locomotive is so much larger and more efficient than the locomotive of thirty years ago that a comparison between them is scarcely possible. It would seem, however, that the limit to the capacity of the steam locomotive has been closely approached, if it has not already been reached, and where greater capacity is required, another type of motive power must be used. The other type of power, in the shape of the electric locomotive, is in the field prepared to take an increasing share of the load from the boilers and cylinders of the steam locomotive; to take the load where the inherent limitations of the steam locomotive make it unequal to the demands upon it or its use undesirable or impracticable.

The far-seeing railway operator is studying the subject of electrification more seriously than ever before, and he confidently looks to the electric locomotive to help him out of many difficulties. He starts with the desire for more power and with the idea that he will substitute the electric locomotive whose power can be made anything that is desired, for the steam engine whose power is limited by the boiler it carries. While there is no question as to the ability of the electric locomotive in this respect, he finally realizes that electrification requires practically a revolution in operating methods before all of its advantages can be secured.

Many of the old ideas that have grown up around the steam locomotive will have to be modified or abandoned and new methods introduced. The length of engine divisions, ruling grades, distribution of coal and watering stations, dispatching, the tonnage and speed of trains, the design of stations and terminals, have all hinged around the steam locomotive. This revolution will not have to take place all at once,—it will be rather a gradual evolution of new methods that will be worked up by the more progressive operators, as the advantages and possibilities of electrification develop before them.

Among the many features that will become evident to the operating man making a close study of the subject of electrification, are the following:

(1) The power that can be applied to a train is in no way limited by the size of the individual motive power unit. The electric locomotive derives its power from a central power station which may carry the entire railway load and a large industrial load at the same time. Theoretically, the locomotive can draw the maximum amount of power that can be utilized at one point in the train. Whatever may be the size or capacity of the individual motive power unit, it places no limit on the amount of power that can be controlled from one cab, since two or three, or half a dozen if need be, of these units may be coupled together and operated on the multiple unit system like a train of suburban or subway cars. A locomotive may then be an aggregation of motor trucks with a single engineer's compartment. Practically the only limit to the tractive effort that can be controlled from this one point is the strength of the drawbars. Drawbar pull, however, is not the only way in which the greater power is developed; speed accounts for fully as much and it will soon appear that the highest economical speed for traffic movement can be met by the electric freight locomotive; this may be two or three times as great as that of the steam locomotive. This is particularly apparent on the mountain grades where the heaviest freight trains when pulled by steam locomotives make from 7 to 10 miles per hour, while the same trains or heavier ones pulled by electric locomotives run from 14 to 20 miles per hour. The electric locomotive makes it possible to operate freight trains at practically any desired speed. From this it can be seen that freight trains can more closely approximate passenger train schedules and thus greatly increase the track capacity.

In passenger service it is probable that it will not be considered economical to operate trains at much higher maximum speeds than are attained with steam locomotives. However, it will be possible to operate at a more uniform speed and with fewer delays. Heavy grades can be covered at as high speed as is safe or economical, so that if desired a higher schedule speed can be maintained with the same maximum speed as at present.

(2) The length of the division on the railroad will be no longer limited by the locomotive. Electric locomotives make the run daily over the entire electrified section of the Chicago, Milwaukee & St. Paul Railway between Avery and Harlowton, a distance of 440 miles, and are repeating this trip over and over until 4,000 miles or more have been covered before the locomotive goes to the shop for anything but the casual light inspection it receives at ends of runs. There is no question but that the locomotive division could be much longer than 440 miles if it were convenient or desirable to make it so. If the large ocean liners can keep their engines running for a couple of weeks without stop, and Pullman cars can run thousands of miles, there is no reason why electric locomotives cannot operate equally well, and take equally big runs. Under the conditions of operation on the Chicago, Milwaukee & St. Paul Railway, even with only two passenger trains each way per day, one locomotive has made more than 11,000 miles in a single month.

*Abstract from an address by N. W. Storer, general engineer, Westinghouse Electric & Mfg. Co., delivered before the Franklin Institute, Philadelphia Pa., April 14, 1921.

With the schedule arranged to suit, this mileage might easily be from 15,000 to 20,000 miles per month. This, of course, means a great reduction in the number of locomotives required. A record for a continuous 24 hour run of 766 miles has already been reached by the passenger locomotives on this road.

(3) Electrification permits radical changes in terminals, due partly to the absence of smoke, dirt and noise, and very greatly to the use of multiple unit car equipments for the suburban traffic. The absence of the smoke and dirt results in a change in the entire character of the neighborhood surrounding the railroad and its station. The railway is free to take full advantage of its aerial rights in the construction of hotels, office buildings, warehouses, etc., over the tracks, which with steam locomotives must be left open. What this one feature alone means in a congested center like the Chicago district, for instance, where there are 4,500 miles of steam railroad track in operation, it needs no words to tell. Wherever the value of real estate is high, the land covered by the railroad is very valuable and its use for building purposes can be made a source of revenue to the railway,

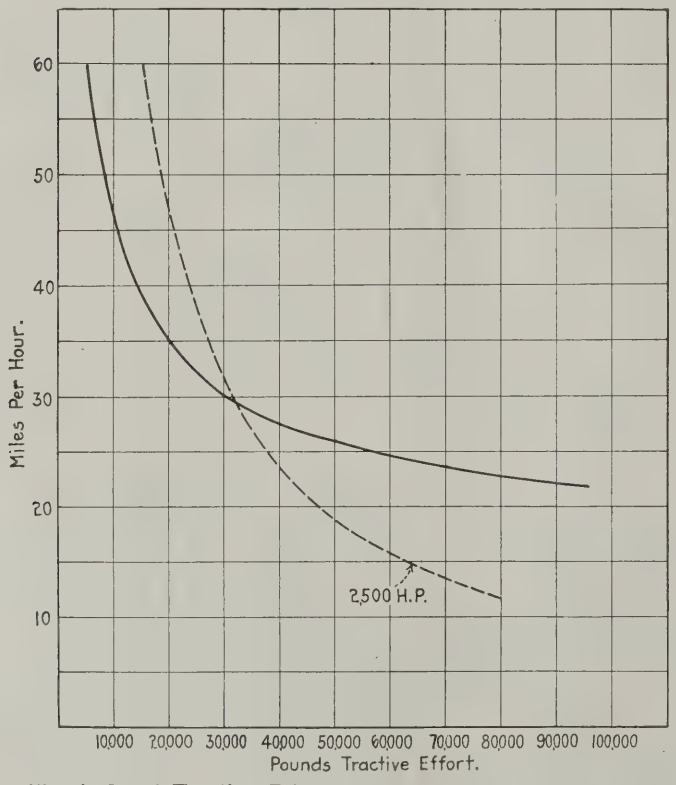


Fig. 1—Speed Tractive Effort Characteristics of D. C. Series Locomotive 4-6-2+2-6-4 Class

which will go far towards paying the cost of the electrification.

The absence of smoke and dirt makes it safe and desirable to enter the city in a subway, and to have the tracks on two or more levels with a corresponding increase in capacity of the station site. This in the future may, in fact, be the only possible answer for the increase in needed capacity.

The use of multiple unit equipments makes large increase in the terminal capacity, especially where it is a stub end terminal like that at Broad Street, Philadelphia, by decreasing the number of idle movements in the terminal which are necessary with the steam locomotive but are not required at all for the electric. All of these advantages are familiar to everyone who is interested in the subject.

A considerable improvement in terminals will also be made in the handling of freight. The electric switcher lends itself to any desired arrangement of terminal and yards. It has proven its value in the great Harlem River yards of the New York, New Haven & Hartford Railway where the switchers remain in continuous service a month or more at a time with no more attention than the crew can give them.

(4) The advantage in the use of the electric locomotive

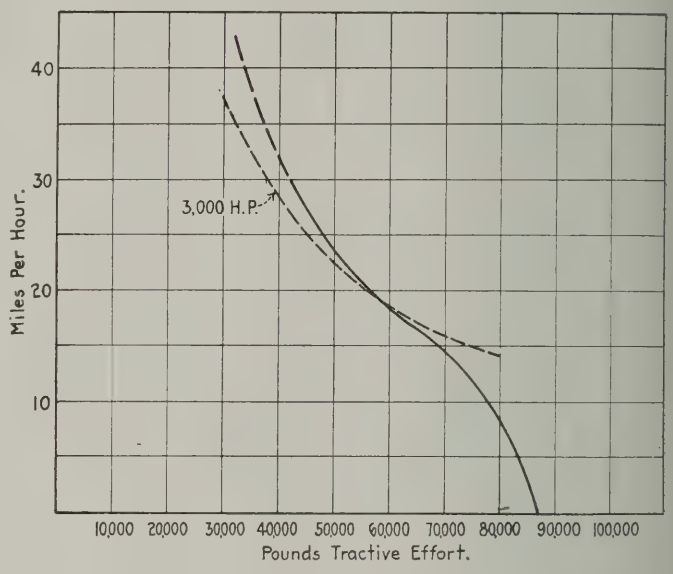


Fig. 2—Speed Tractive Effort Characteristics of Steam Locomotive

for long tunnels is obvious. This has been recognized for many years, and many long tunnels that were objectionable with steam locomotives have been electrified with the best of results. The Simplon Tunnel, constructed under the great mountain range between Switzerland and Italy, was based wholly upon electrical operation. In fact, it would probably be impossible to operate a tunnel 12 miles long in any other way at this time. This characteristic of the electric locomotive will undoubtedly be taken advantage of hereafter in eliminating many long and expensive mountain grades by tunnelling through the mountains. There seems to be no reason why tunnels of much greater length should not be used.

(5) Electrification obviously means conservation in fuel. Just how great this conservation will be is a mooted question. Some enthusiastic electrical exponents claim it will save two-thirds of the fuel that is now used by the steam locomotive. Some steam locomotive enthusiasts, on the other hand, deny that anything approaching this saving can be effected, basing their statements on a comparison with engines of the latest design and the best practice. Undoubtedly neither is wholly right, but it cannot be disputed that the consumption of fuel is attended with every refinement continuously in a modern power house, and that this can never be hoped for when this responsibility rests upon the performance of each of the thousands of locomotive firemen on steam locomotives. Bearing this in mind, it seems certain that, on the average, an electrified railway with modern steam power houses would not use more than one-half of the

fuel that would be required for the railway under steam operation.

(6) Another thing electrification means which is of vastly more importance to the management, is the greater effectiveness of labor. This follows from the greater capacity which can be secured from the railroad machine.

(7) Last but not least among the things which are to be mentioned as following electrification of a railroad, is increased reliability of the motive power. In every case where electric power has supplanted steam, this has been inevitably attended with improvement in regularity and reliability of train movement.

What are the characteristics of the electric locomotive

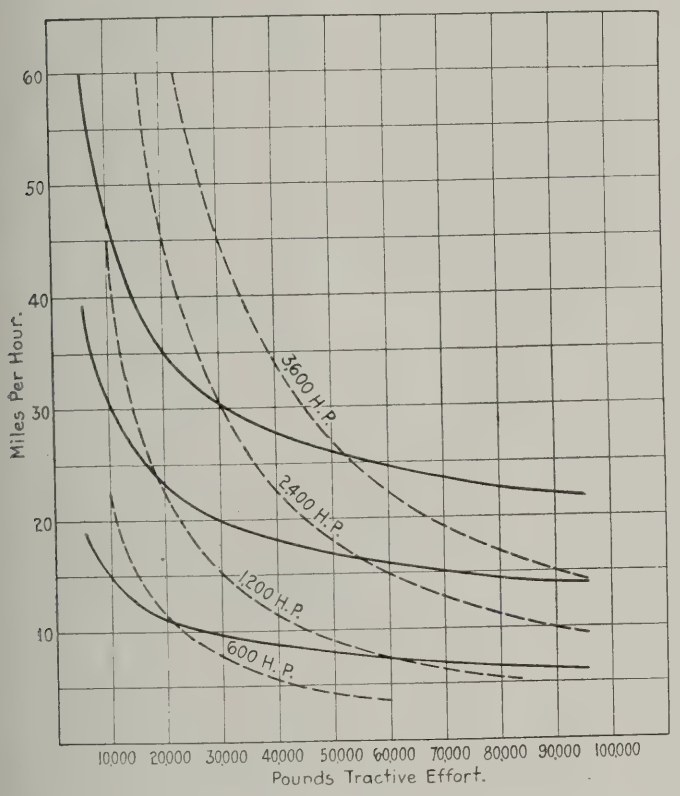


Fig. 3—Speed Tractive Effort Characteristics of D. C. Series Motor Locomotive 4-6-2+2-6-4 Class, Three Speed Control

that make it so desirable; that fit it so admirably for railway service?

(1) Its maximum tractive effort is from two to four times its normal continuous running tractive effort. This depends for the most part on the coefficient of adhesion which is used for the normal tractive effort. This may vary anywhere from 5 per cent to 20 per cent of the weight on drivers. Of course, where the normal tractive effort is 20 per cent of the weight on drivers, it would be impossible to secure more than double the normal. Ordinarily a coefficient at normal tractive effort of 16⅔ per cent will not be able to give more than 100 per cent above normal as a maximum, but, as is usually the case, where the normal tractive effort requires only from 10 per cent to 15 per cent adhesion, it is possible to develop as much as three times the normal. This compares very advantageously with the steam locomotive whose maximum tractive effort or given horsepower rating is comparatively close to the normal running. It means a great deal in the operation of the locomotive; it makes it comparatively easy to start its normal train in the worst position and also to start it very quickly without jerk. Everyone knows who rides on our steam trains that a heavy passenger train is usually started with a jerk. The reason for this is simply that the steam locomotive at the head of the train must jerk it if it is to start at all, because its maximum tractive effort is so close to that required for pulling the train after it is started that it has little margin. The locomotive may be amply large to pull the train at high speeds but it cannot start it without a heavy jerk. The electric locomotive, on the other hand, can start with a steadily inceasing tractive effort until the train begins to move, and the maximum tractive effort can be maintained until full voltage is applied to the motor.

(2) The capacity of the electric locomotive is limited by the heating in the motors. The necessity with an electric locomotive is to keep the temperature of the parts down, which is just the reverse of that of the steam locomotive. For this reason, the electric locomotive can easily develop considerably greater power in cold weather than in warm weather. Here, again, it is just the reverse of the steam locomotive.

(3) Practically all of the wearing parts of the electric locomotive have normally a long life. Therefore, all that

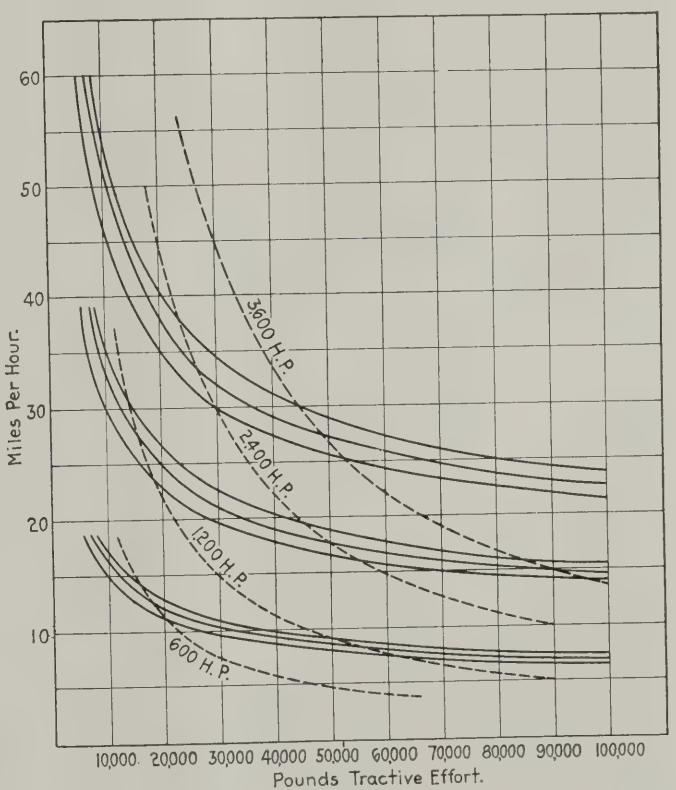


Fig. 4—Speed Tractive Effort Characteristics D. C. Series Motor Locomotive 4-6-2+2-6-4 Class, Nine Speed Control

is needed to keep the locomotive on the road is to secure proper lubrication, keep the bolts tight, brakes adjusted and to give an occasional inspection to insure that nothing abnormal has taken place in the equipment. This is the secret of the great mileage which is possible with the electric locomotive; it explains why the locomotive is ready for service so large a part of the time; it is the reason that only one-half or one-third as many electric locomotives are required for a given service as would be required for steam operation; it explains why the

round-houses and inspection forces can be reduced to such a small limit; why the intermediate division points are eliminated; it gives the reason for the great reliability of the electric locomotive.

The foregoing are some of the most prominent general characteristics of the electric locomotive. It must be understood, however, that there are many other characteristics, depending on the specific type of locomotive that is under consideration, in other words, on the system which is adopted for the electrification. These characteristics are apparent chiefly in the speed and tractive effort curves. The three types of locomotives which are in use in this country today are, first, direct-current with series wound motors; second, single-phase locomotives with commutator type motors having series characteristics: third, constant speed locomotives fed either from a single-phase trolley by means of phase converters or from double trolleys carrying three-phase current.

Direct-Current Locomotive

The series wound motor is the one which is in practically universal service the world over where direct current is used. Its characteristics are especially suited for railway service, since the speed curve falls rapidly as the

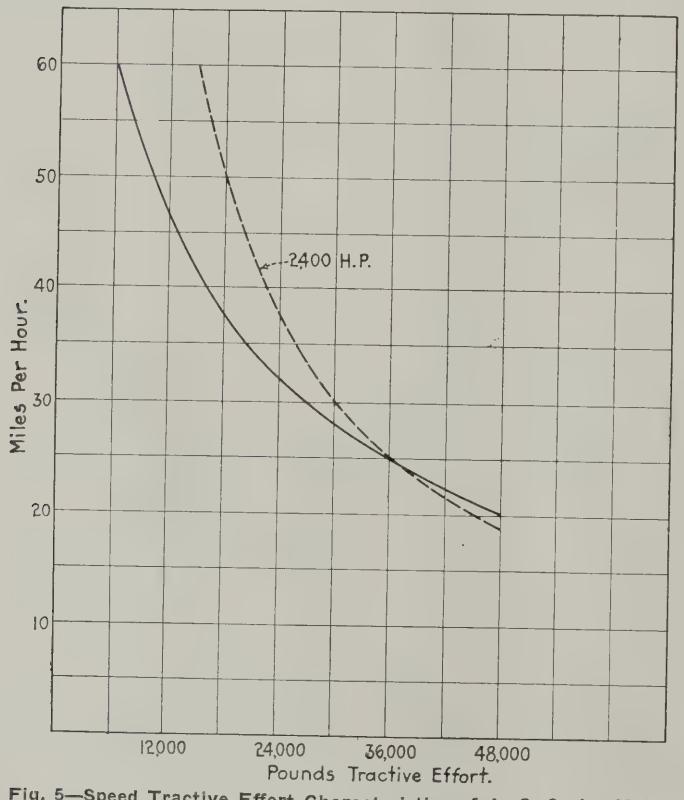


Fig. 5—Speed Tractive Effort Characteristics of A. C. Series Motor Locomotive 2-6-2+2-6-2 Class, Constant Voltage

tractive effort increases, which gives the best characteristic for dividing the load, especially where a considerable number of driving units are operating in the same train. It also permits the motor to handle a much heavier load or a normal load on much heavier grade than would be possible if the speed did not fall with the increase in tractive effort. It gives, in a way, the same effect as the shifting of gears on an automobile enables it to exert an unusual amount of effort with a relatively small engine. The method is not the same, but the result obtained is similar.

The solid curve on Fig. 1 shows the performance of the direct current series motor. Thus, it can be seen that this slowing down of the speed with increased effort relieves, to a certain extent, the whole electrical supply system; the trolley, the transmission lines, and the generating units; from the peak loads caused by starting heavy trains or by hauling over heavy grades. When lighter grades or level track is reached, the characteristics of the series motor cause it to speed up very rapidly, as shown by the shape of the curve, so that full advantage is taken of the falling off of the load by increasing the speed. While running over a varying pro-

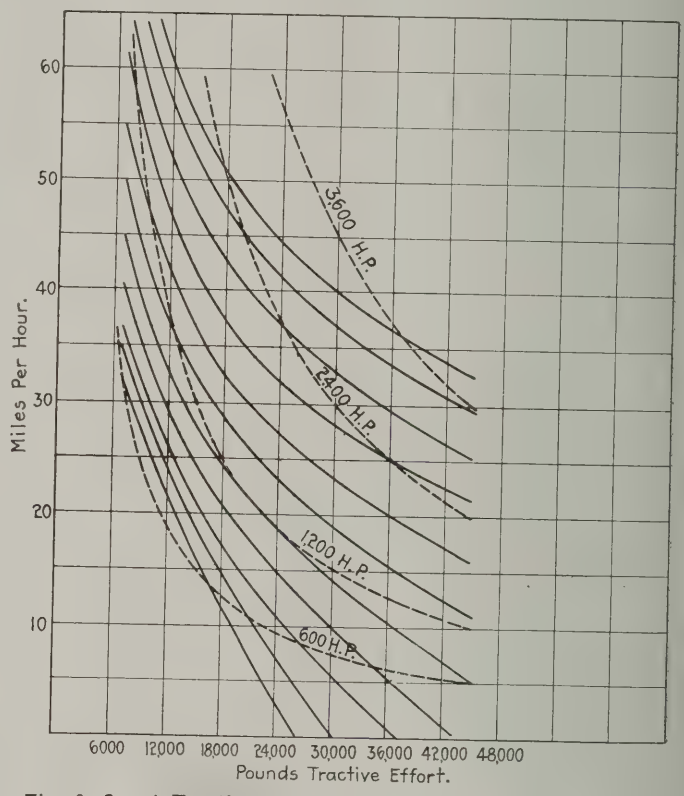


Fig. 6—Speed Tractive Effort Characteristics of A. C. Series Motor Locomotive 2-6-2+2-6-2 Class, Voltage Control

file, it can be seen that the speed of the motor will vary much the same as that obtained with a steam locomotive. Speeds will be considerably reduced on heavy up grades, but may be quite high on level track, and as high as the roadbed will permit on down grades. A train running behind time may be pushed to the limit at every opportunity, and the time made up.

On all of the figures, in dotted lines are plotted a series of constant horse-power curves. That is, the speed and tractive effort read from any point on a given curve will produce a constant horse power. The direct current motor curves at the higher speeds resemble these constant horse power curves, and run very nearly parallel to them. On Fig. 2 is plotted a curve showing the speed-tractive-effort characteristics of a modern steam locomotive. This curve has the desirable faculty of following the shape of the constant horse power curves very closely. On the other hand, however, it does not have the same desirable characteristic at the heavier tractive efforts which is evident on the electric motor curve, namely, that of rapidly increasing its pulling power as the load increases. The torque of a steam locomotive is limited definitely by the ability of the boiler to supply steam and the cylinders to

utilize the steam. This is shown by the rapid falling off of the curve when this point is reached.

These curves then illustrate the advantage of the series motor characteristics which approach the constant horse power curve over a certain portion, and at the same time permit of exerting very high tractive efforts when necessary.

With the series motor, the only means of controlling the speed is by varying the voltage on the motor. This may be accomplished by inserting resistance in series with the motor, but this is very inefficient, and cannot be used for other than acceleration. The common method used for obtaining this speed control with d. c. motors is to connect the motors in different series and series-parallel

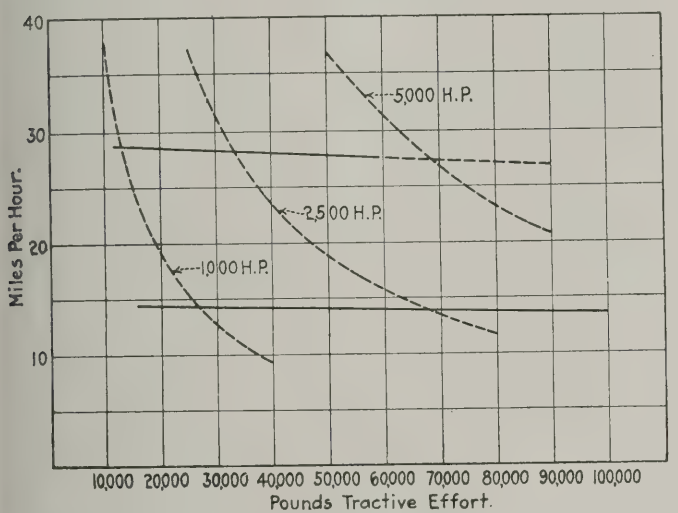


Fig. 7—Speed Tractive Effort Characteristics of A. C. Induction Motor Locomotive 2-4-4-2+2-4-4-2 Class, Two Speed Control

combinations. Fig. 3 shows three speeds obtained by connecting the motors: first, all in series so as to give ⅓ voltage and speed; second, in series-parallel to give ⅔ voltage and speed; and third, in parallel to give full voltage and speed. This method covers the speed range fairly well. Fig. 4 shows the addition of six more running speeds, making nine in all. These additional speed-curves are obtained by varying the effective turns on the motor field. With the use of these "field control" points, the range in speed is very effectively covered. This set of curves shows the characteristics obtained on the new 3,000-volt, direct current passenger locomotives built for the Chicago, Milwaukee & St. Paul Railway.

Alternating Current Locomotives

Fig. 5 shows the speed torque characteristics of an alternating current series motor locomotive. This curve is somewhat more steep than a direct current series motor curve, and more nearly approaches the constant horse power curve shown by the dotted lines on the same figure. This type of motor does not, however, have the ability to produce the very high starting torques which it is possible to obtain from the direct current motor, because of certain commutator limitations when drawing heavy currents. On the other hand, the speed control on this motor is very easily and efficiently obtained by varying the voltage applied to the motors. Power is furnished from different taps on the transformer, and the different speeds obtained as shown on Fig. 6, without in any way altering the grouping of the motors. These curves show the speed control obtained on the latest type passenger locomotive built for the New York, New Haven and Hartford R. R.

The other motor used for railway work is the alternating current induction motor. This motor is essentially a constant speed motor. Its characteristics are shown on Fig. 7 and are quite different from either of the other two motors discussed. Other running speeds can be obtained with this motor by varying the number of poles, and by cascade connections, but it is rarely practicable to obtain more than two running speeds. The curves shown give two speeds, one at 14 miles per hour, and the other at 28 miles per hour. These speeds are as obtained on the Norfolk & Western freight locomotives. Acceleration is obtained by varying the resistance in the secondary of the motor, but these resistance points cannot be used as running points. This type of motor is capable of producing very heavy starting torques, and of carrying very heavy loads, but on heavy loads the speed is maintained at practically a constant value and the power required increases practically with the tractive effort. It is necessary, therefore, to have a motor of greater capacity than with the series motor, in order to take care of the peak loads. Some care is also necessary when operating more than one locomotive of this type in the same train, or even with different motors on the same

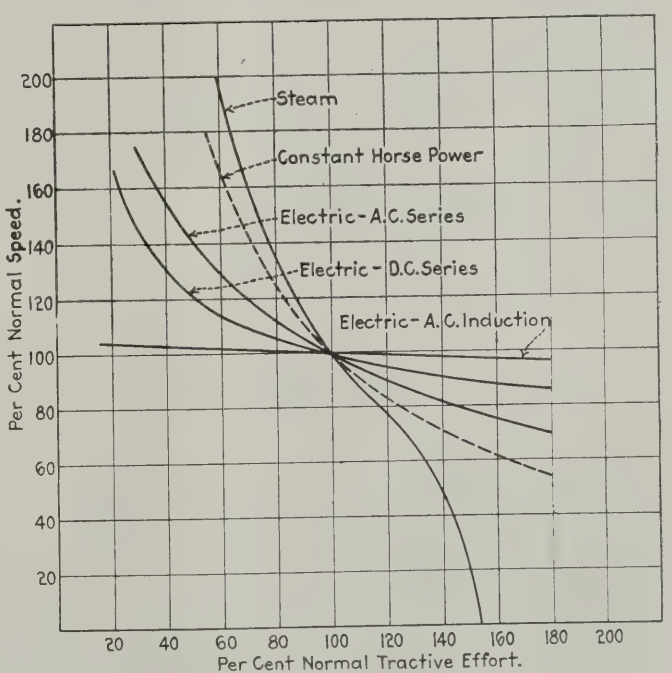


Fig. 8—Speed Tractive Effort Characteristics of Steam and Electric Locomotives

locomotive, to balance the load between them and not overload one motor or one locomotive with more than its proportion of load. A slight difference in wheel diameter may cause considerable overloading, unless special means are used for balancing.

There has been considerable discussion among railroad men as to the advantage and disadvantage of the constant speed characteristic. The claim is made by some that it is a decided advantage to be able to start a train from one terminal and know that, barring break-down, it will run at the same speed up hill and down, and arrive at the other terminal at a certain definite time. On the

other hand, it is claimed that the ability of the series motor to take advantage of every opportunity for making speed is a very desirable characteristic, when it is necessary to make up time. A series type locomotive of a given rating will always be able to make a better schedule than a constant speed locomotive of the same rating.

Figure 8 gives a set of curves showing the characteristics of the various motors and a steam locomotive. These curves are plotted in percentages so as to be comparative.

Regeneration

Regeneration, or regenerative braking, is another characteristic of the electric locomotive, the advantages of which cannot be over-emphasized. While this feature makes it possible to reclaim some of the energy stored in a train when it reaches the top of a heavy grade and starts to go down, yet this saving in power does not by any means represent the full or most important benefit to be derived from it. Perhaps the most important advantage, and the one which will appeal most forcibly to the railway operating man, is the ease of control and safety provided by this form of braking as well as the reduction in wear on brake-shoes and tires.

Regenerative braking may be obtained on any of the three classes of locomotives previously mentioned. The methods of providing for this, of course, are entirely different.

In the constant speed locomotive with induction motors, regeneration is automatic. When the locomotive, in running down grade, reaches a speed above synchronism the motors act as generators excited from the line. In this respect the constant speed locomotive has a great advantage but the speed is fixed.

The series type of motor, whether A. C. or D. C. requires excitation from some separate source, and therefore involves some additional apparatus on the locomotive.

D. C. motors may be excited from a line driven motor generator set, or an axle driven generator; or, one or more of the main motors may be used as exciters for the others. Regenerative braking has been thoroughly tried out on the St. Paul and is very successful. It permits operation on the down grades at any desired speed and holds the train without surge or jar. The efficiency of regeneration is approximately the same as that of motoring.

Alternating current series motors have been used with regenerative braking to a limited extent and various schemes are proposed for excitation. The taps on the transformer enable the speed to be controlled all the way from maximum to a stand still and in this respect it is superior to all others. Some of the schemes for excitation are very simple but usually have the disadvantage of either limited braking power or low power factor, or both. To get the most out of regeneration will require excitation from a phase converter or one of the main motors. With that the locomotive can exert a high braking effort and will have a good power factor.

The electric locomotive is so flexible and capable of so many things that it is likely to be overloaded with all kinds of devices that are not at all essential to its operation. These add very greatly to the apparent complication but after all do not materially affect the reliability. The trend of the times is towards simplification—the reduction of the locomotive to its lowest terms consistent with good operation. This is undoubtedly the way to get the lowest first cost and maintenance charges.

Regenerative braking should be applied on locomotives which are to be operated over heavy grades, but for level or light grade sections the advantage will hardly be worth the complication.

In conclusion, it may be said that the electric locomotive is so flexible that it can be designed to meet practically any reasonable operating condition, while its unlimited capacity, its great mileage possibilities, its reliability, its low cost for power, and low cost of maintenance, all make it especially attractive to the railway operator.

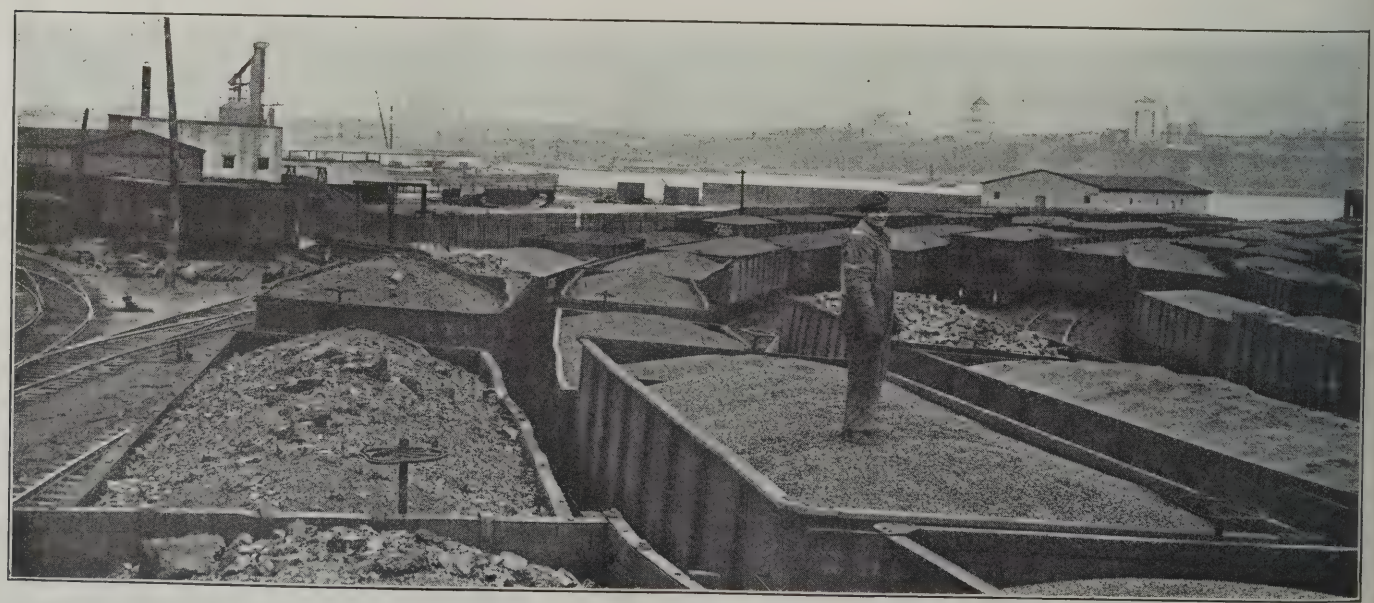


Photo by Ewing Galloway, N. Y.

In the New York, Susquehanna & Western Yard at Undercliff, N. J.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of this Important Application

By Charles W. T. Stuart

X. Installing a New Car Lighting Equipment

THERE are many different classes of cars and types of car lighting equipments on the various railroads today, but practically the same methods are used in installing each equipment.

The installing of a new car lighting equipment is a grade of work that ranks high in importance. High efficiency in this work is a big factor in keeping down the maintenance cost during the life of the equipment, as a small defect in the wiring of a car may be the cause of

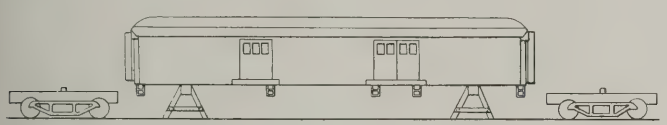


Fig. 1—Trucks Removed and Car Placed on Trestles for Application of Axle Equipment

big expense; for power in taking the car out of service and placing it on a shop track, for labor in locating and removing the defect, and for loss of revenue due to the car being out of service.

The electrician in the act of installing a new car lighting equipment first receives a complete set of blue prints from the electrical engineer. These prints show the plan of the entire equipment. The material for the job is furnished by the store department and the placing of the car to be equipped is cared for by the transportation department. The car erecting shop is the most suitable place for this particular line of work, as it is equipped with the necessary facilities that are not to be had in the other shops. In the car erecting shop, the trucks are taken from under the car and the car is placed on heavy trestles. This gives the electrician an excellent opportunity to run his conduit and do other necessary work under the car floor.

To give a general idea of the methods used in the procedure of the work in installing a new car lighting equipment suppose we cover briefly the application of a particular type of equipment to a certain class of car. In most cases, the car lighting equipment is installed during the building of the car, but in this case, for the benefit of the maintainer, who is compelled to renew and repair certain parts of a car lighting equipment after the car is built, suppose we take a steel baggage car completely built, and cover the application of a new Safety F-2 Axle Lighting Equipment. We might first cover a straight storage system and then an axle generator system, but since the axle generator system is practically a straight storage system with the addition of an axle generator and regulators, the application of the axle generator equipment will cover both.

Material

The blue prints having been received, the next step is to determine what material is needed, etc.

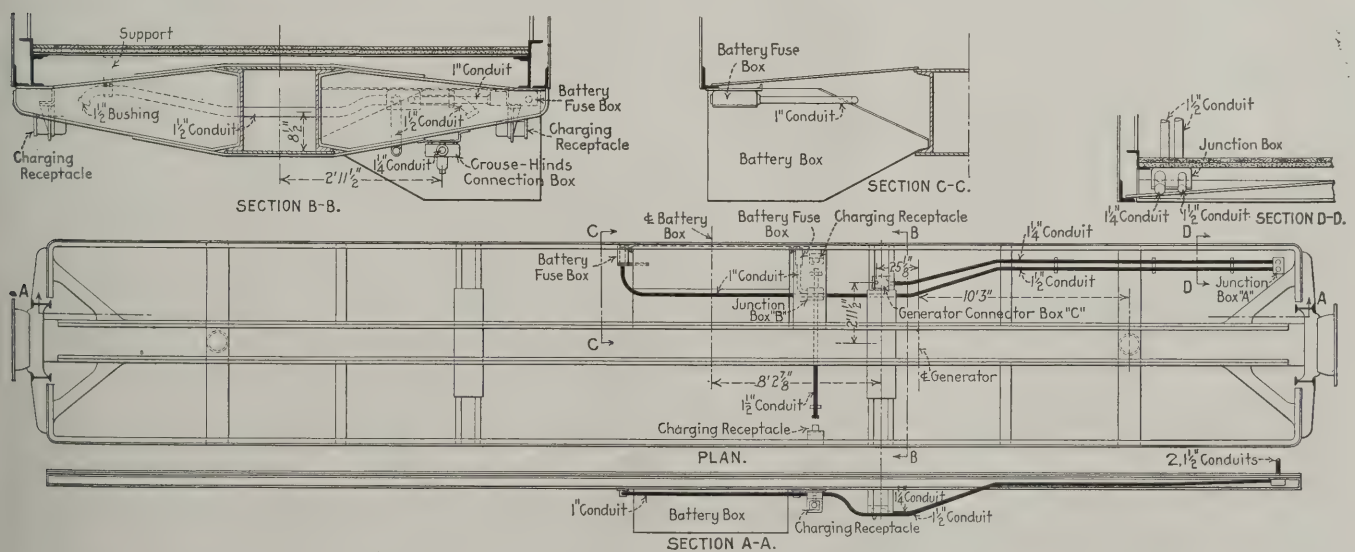


Fig. 2—Diagrams of Conduit Runs Under Floor of Car. Sectional Drawings Show Arrangement of Conduit at Various Points

The following is a list of material required for this installation:

- 1 axle generator.
- 1 axle generator regulator.
- 1 lamp regulator.
- 1 Sangamo control panel.
- 8 lighting fixtures (complete with boxes).
- 2 three-way snap switches.
- 1 four-way snap switch.
- 1 plug cut-out.
- 1 steel regulator cabinet.
- 1 suspension bracket.
- 1 generator shaft.
- 1 tension spring bracket.
- 1 tension rod.
- 1 tension nut.
- 1 tension spring.

1 tension spring guide.
1 tension wheel.
1 fulcrum.
1 suspension link.
100 ft. ¾" conduit.
20 ft. 1" conduit.
40 ft. 1¼" conduit.
40 ft. 1½" conduit.
90 ft. No. 0 wire.
50 ft. No. 4 wire.
25 ft. No. 8 wire.
326 ft. No. 12 wire.
2 battery fuse boxes (complete)
2 junction boxes.
2 junction box covers.
5 conduit support.
3 switch condulets.
1 generator connector box.
2 Dossert connectors.
2 charging receptacles (complete)
Bolts, nuts, screws, solder, tape,

Placing the Car on Trestles

The work of jacking the car, removing the trucks, and placing the car on trestles, Fig. 1, is performed by the car erecting shop force. With the car on trestles, the false bottom, which is made of galvanized iron, lined with asbestos, can easily be removed. This line of work is under the direction of the tin shop.

First Step—Battery Box and Cabinet

Mark off the location of the battery box and regulator cabinet and have them installed. The location of the battery box, Fig. 2, is 8 ft. 2⅞ in. from the cross beam to the center of the battery box. The regulator cabinet is shown in Fig. 3, to be located in one corner of the car. The regulator cabinet and battery box are made of sheet steel and their application comes under the direction of the cabinet shop.

Second Step—Conduit

Mark off the location and then apply the various junction boxes that form the terminal points for the conduit. Located under the floor, Fig. 2, shows a battery fuse box at each end of the battery box, two charging receptacles—one at each side of the car—junction boxes *A* and *B*, and generator connector box *C*. With these installed, the conduit is run as follows: a 1 in. line of conduit from the battery box to each battery fuse box and then to the junction box *B*; a 1½ in. line of conduit from each charging receptacle to the junction box *B* to the junction box *A*, and two lines from the junction box *A* to the regulator cabinet; a 1¼ in. line of conduit from the generator connector box *C* to the junction box *A*. The various conduit supports are then applied, completing the conduit work under the car.

The lighting fixtures, Fig. 3, are located down the center line of the car. A four-way switch is placed on the side near one of the sliding doors, and a three-way switch is placed at each end of the car to the right of the door. After the lighting fixtures are installed they are connected to the regulator cabinet by a line of ¾ in. conduit, also shown in Fig. 3.

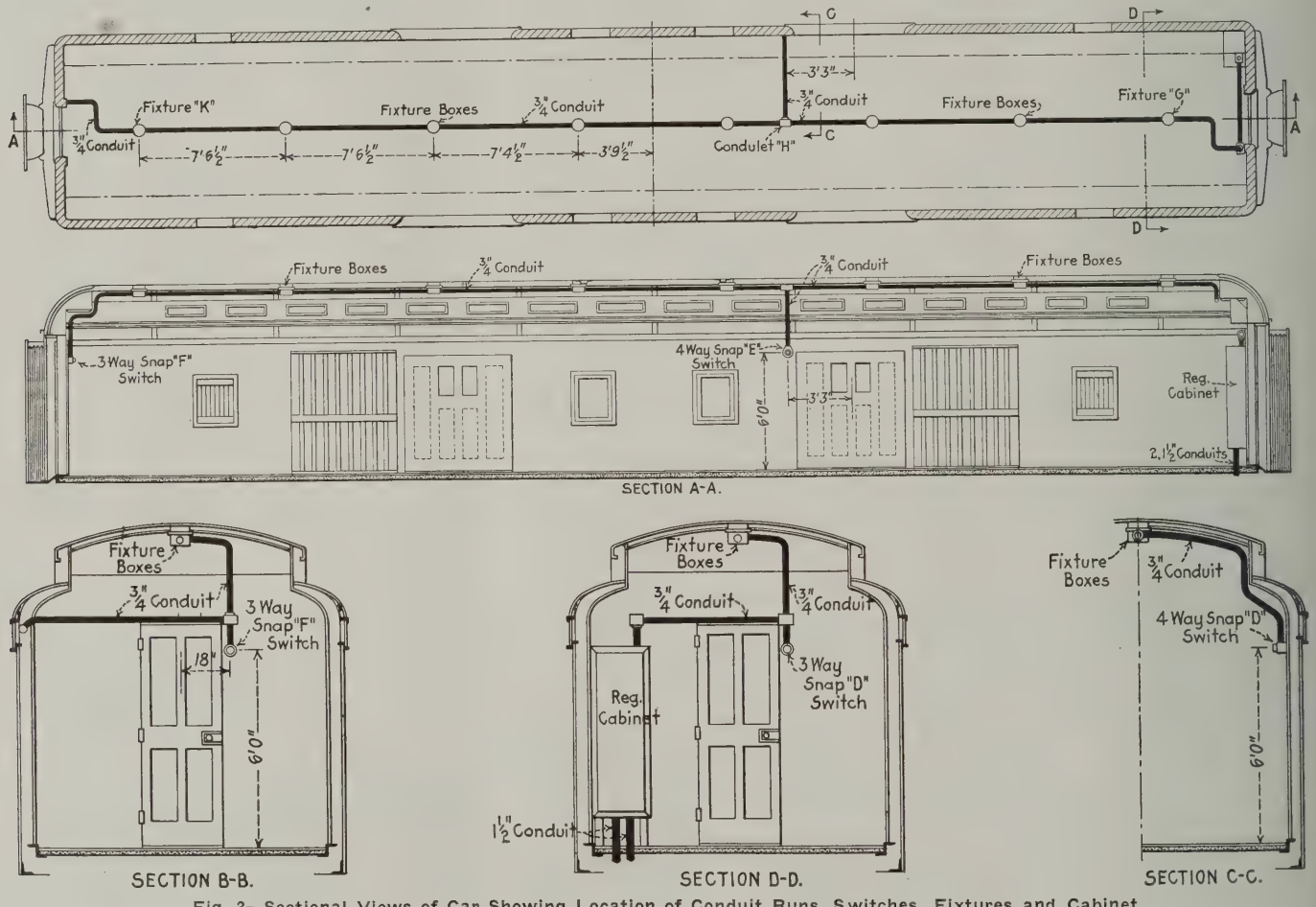


Fig. 3—Sectional Views of Car Showing Location of Conduit Runs, Switches, Fixtures and Cabinet

Third Step—Wiring

Looking over the wiring diagrams, Figs. 4 and 5, we observe that No. 0 wire is run from the battery and

charging receptacles, through the 1½ in. conduit to the regulator cabinet, and that two No. 4 generator wires and one No. 8 field wire are run from the generator connector box through the 1¼ in. conduit to the regulator cabinet. The three No. 0 main battery wires are cut the proper length, then connected to a steel fish or pull wire and pulled from the junction box *B*, Fig. 2, to box *A*, and

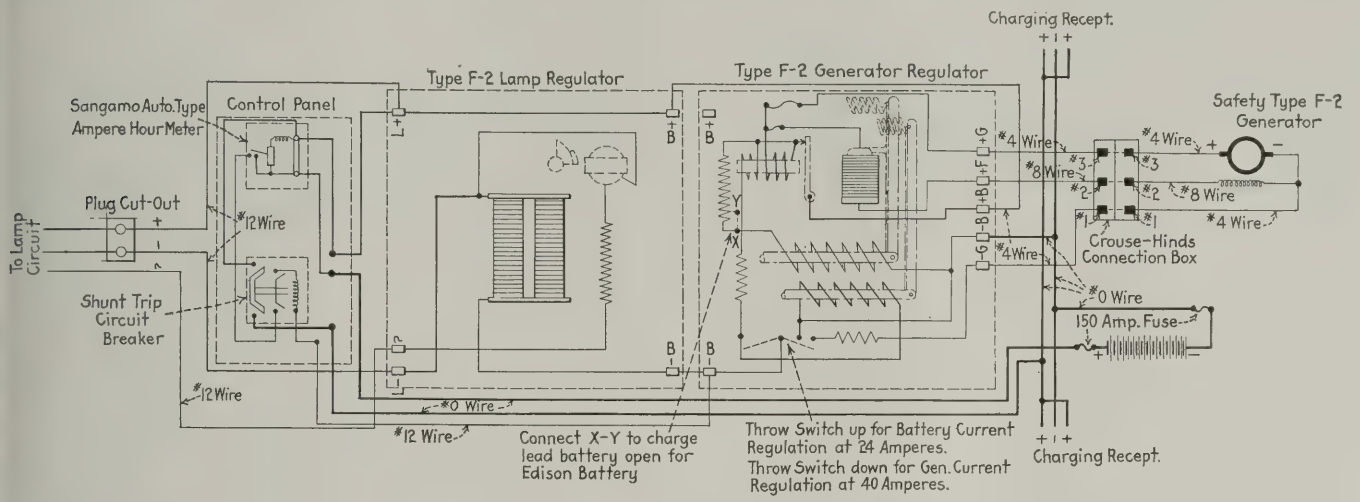

Charging Recept.
Type F-2 Lamp Regulator
Type F-2 Generator Regulator
Sangamo Auto. Type Ampere Hour Meter
Control Panel
Safety Type F-2 Generator
Plug Cut-Out
To Lamp Circuit
#12 Wire
#4 Wire
#8 Wire
Crouse-Hinds Connection Box
Shunt Trip Circuit Breaker
#0 Wire
150 Amp. Fuse
Connect X-Y to charge lead battery open for Edison Battery
Throw Switch up for Battery Current Regulation at 24 Amperes.
Throw Switch down for Gen. Current Regulation at 40 Amperes.
Charging Recept.

Fig. 4—Circuit Arrangement of the Generator and Lamp Regulating Panels

enough to reach from the three-way switch *D*, Fig. 3, to the four-way switch *E*, two, long enough to reach from the three-way switch *F* to the four-way switch *E*, and two wires, one long enough to reach from the regulator cabinet to the three-way switch *D*, and the other long enough to reach from the regulator cabinet to the fixture *G*. The six wires when cut are coiled in respective pairs

then to the regulator cabinet. The three ends hanging at box *B* are connected to the battery and charging receptacle terminals. The two No. 4 generator wires and the No. 8 field wire after being cut the proper length, are connected to a fish wire and pulled from the generator connector box *C* to the junction box *A*, and then to the regulator cabinet. The wiring diagram, Fig. 5, shows the size of the lighting circuit wires to be No. 12, and

and pulled into the conduit starting at condulet *H*. Four wires are pulled through the conduit from the condulet *H* to fixture *K* and from condulet *H* to fixture *G*. The four ends of these wires left hanging at condulet *H* are pulled to the four-way switch *E* and the four ends hanging at fixture *G* are pulled, two to the regulator cabinet and two to the three-way switch *D*. In pulling these last four wires, a fifth wire should be pulled from the regu-

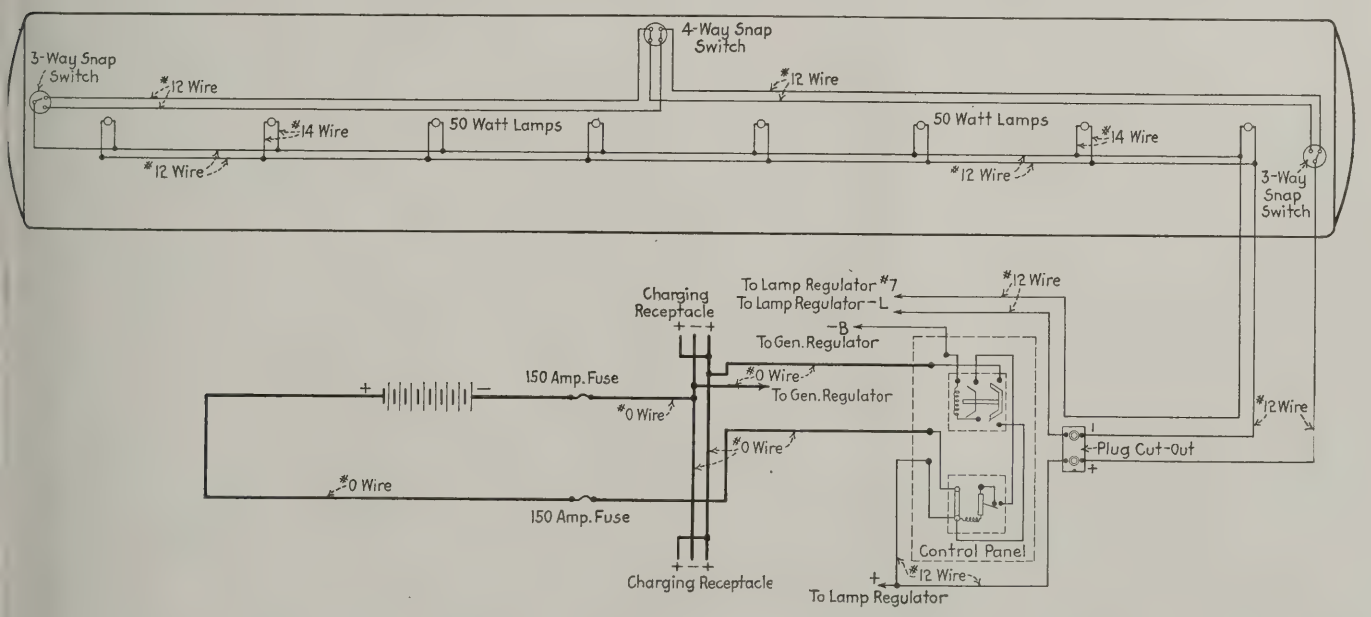


Fig. 5—Wiring Dirgram of Car Showing Schematic Wiring of Regulator Panels

that although all the lamps are connected to one circuit, four wires are used. The current to the circuit is fed from the branch block by two wires, but a third wire is required in connecting the switches for three and four-way control and a fourth wire is used to control the main lamp regulator coil circuit. In wiring the lighting circuit, the No. 12 wire is cut into six lengths, two of these long

lator cabinet to the outlet box located at the three-way switch *D*, making three wires in all running to the three-way switch *D*.

In pulling the wires through the conduit from one pull box to another, the use of powdered soapstone will be found helpful in preventing the wires from sticking to the conduit.

Fourth Step—Panels

The installing of the control panel, generator regulator panel, lamp regulator panel, and plug cut-out in the regulator cabinet is next in order. First measure the distance between the studs and compare this with the distance between the holes in the slate panel before attempting to hang them, because if these studs are not correctly spaced, the panel corners are very easily broken in forcing the panels over the studs. Lead washers should be placed over the hanger studs and in back of the slate panels to form a cushion, and lock washers should be used in bolting the panels in place to prevent the nuts from working loose from vibration when the car is on the road. In applying the plug cut-out a piece of sheet rubber or other insulating material should be placed back of the cut-out between the porcelain base and the sheet steel locker. This rubber acts as a cushion as well as an insulator.

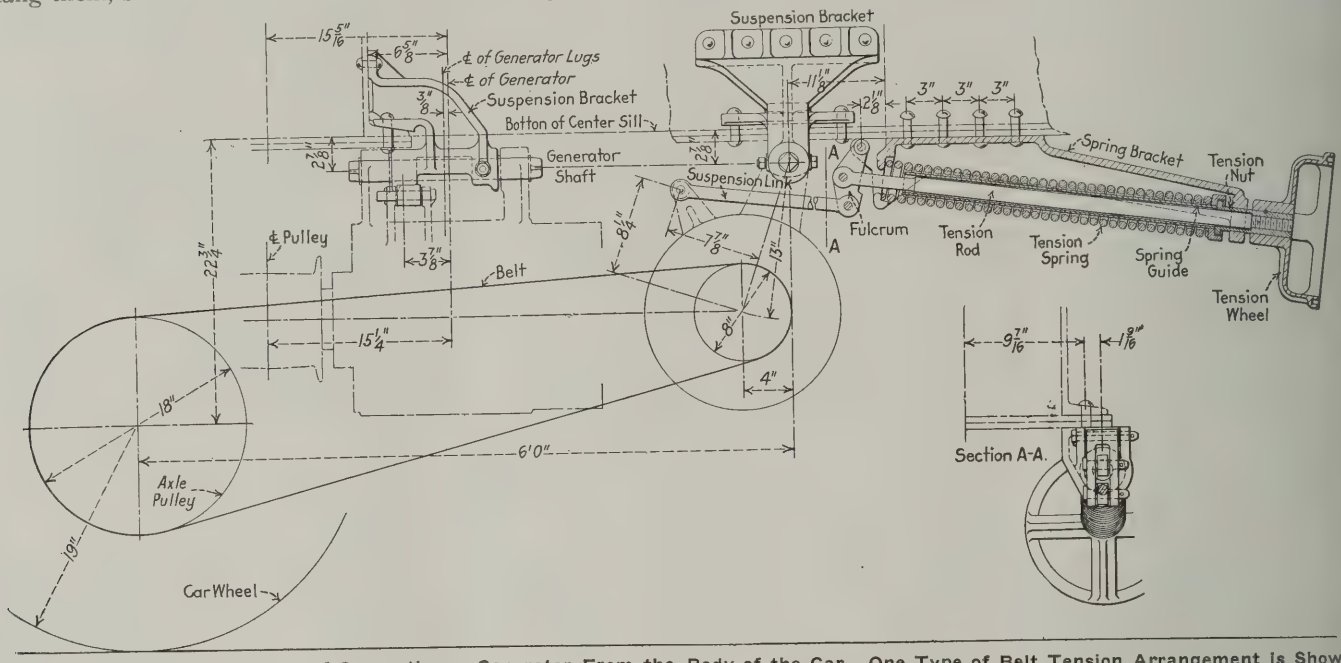


Fig. 6—Illustrating the Manner of Supporting a Generator From the Body of the Car. One Type of Belt Tension Arrangement is Shown at the Right

Fifth Step—Under Car Work

The generator suspension bracket, belt tension device and axle pulley are next to be applied. The suspension bracket, Fig. 6, is a triangular shaped steel casting and is riveted to the backbone or center sill. Fig. 6 shows the location of this bracket to be 6 ft. from the center of the axle to the center of the bracket. The truck is out from under the car when this casting is applied and it is therefore impossible to measure directly from the center of the axle to locate the bracket. This measurement is made by dividing the wheel base of the truck, which is, in this case, 8 ft. by 2, which will give you 4 ft. as the distance from the truck center to the center of axle, and adding 6 ft., will give a distance of 10 ft. from the truck center to the center of the suspension bracket. The truck center casting is fixed to the center sill and it is an easy matter to measure 10 ft. from the center casting and mark off the center line of the bracket. The bracket is bolted to the center sill, lined up and then riveted to the sill. The lining up is accomplished by means of a long bar the exact diameter of the generator shaft, three straight edges and a large steel square. The bar is placed in the suspension bracket, and squared with the straight edges which are held against the side of the car as shown in Fig. 7. In this manner the bracket is lined up square

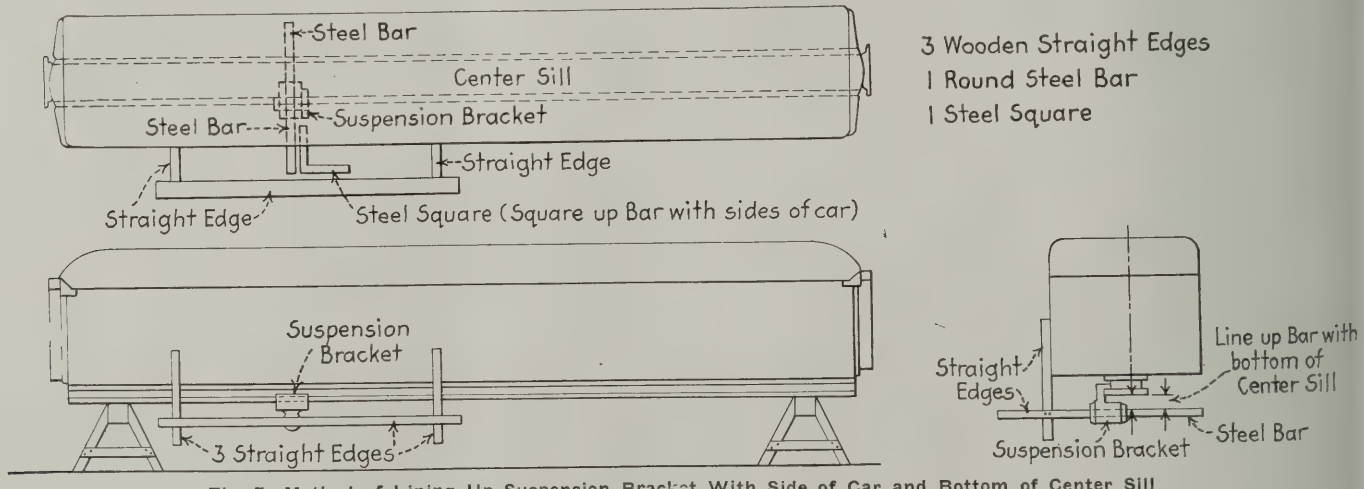


Fig. 7—Method of Lining Up Suspension Bracket With Side of Car and Bottom of Center Sill

with the bottom of the center sill and the sides of the car. It is very important that the bracket be in perfect line because if it is not, the generator will hang crooked and the belt, when applied, will ride off the pulleys. The spring bracket is bolted, lined up and riveted to the center sill, as shown in Fig. 6, and then the spring tension device is assembled. This device consists of a spring, spring guide, tension rod, tension nut, wheel, fulcrum, suspension link and the various connecting pins. Placing the spring into the bracket is a difficult job and a special device is necessary for this work. This device consists of a forged steel box with a screw for compressing the spring and a movable plate for pushing the spring out of the box into the bracket. The box, however, is jacked up against the bracket when the spring is being moved into the bracket, making it a very safe operation. After the tension device is assembled the generator is suspended from the suspension bracket and connected through the suspension link to the spring tension device, as shown in Fig. 6. The axle pulley and bushing are made of pressed steel and in two halves, four bolts to hold the bushing in place on the axle and likewise four bolts hold the pulley in place on the bushing. The axle pulley and generator pulley should be in line and since the generator pulley is in the center of the center sill, the axle pulley should be located at the center of the axle in order that the belt may run true.

The battery is then placed in the battery box and the equipment is assembled ready for the wire connectors. In connecting the wires a magneto and volt-meter are used in selecting the wires at various outlets. All splices should be well soldered and taped. When the wiring is completed, the fuses should be applied and a final test made as follows:

Motor the generator from the battery in each direction. Test the polarity of the charging receptacles with a volt-meter. Test the entire system for grounds with a volt-meter. Test the operation of the lamp regulator by placing the battery on charge and turning on and off the light circuits. Test the operation of the three and four-way switches individually. The regulators are adjusted before leaving the factory and no further adjustment is necessary. The false bottom is then replaced, the trucks placed under the car and finally the belt applied. The car is then ready for service.

An Electric Cutoff Indicator for Steam Locomotives

BECAUSE of the well known fact that there is more or less "creep" in any piston type reverse gear, it has been practically impossible to determine exactly the position of the gear by observing the position of the reverse lever on the quadrant. Tests recently conducted by the C. C. C. & St. L. Ry. on a new moving cylinder type reverse gear, with which an automatic cutoff control was used, required some method of knowing instantly and absolutely the exact position of the gear, because when the automatic feature was in use, the reverse lever was inoperative. Furthermore, it was necessary that every change in the position of the reverse gear should be instantly known in the dynamometer car so that the record of the change might be added to the dynamometer record. In order to accomplish this result the writer devised the following scheme.

As shown in Fig. 1, a fibre strip having a contact button for each position or notch of the reverse lever quadrant was mounted on the top guide of the gear in such a position that the right hand or first button corresponded to the "corner" position and the left hand or twelfth button corresponded to the position of minimum operating cutoff or the twelfth notch on the reverse lever quadrant. The distance then between the centers of the first and twelfth contact buttons was equal to the travel of the gear in the forward motion. Each of the ten intervening buttons was located so as to correspond to the ten intervening notches on the reverse lever quadrant. In the case of the gear shown, a contact finger was mounted on a bracket fastened to the moving cylinder. When the

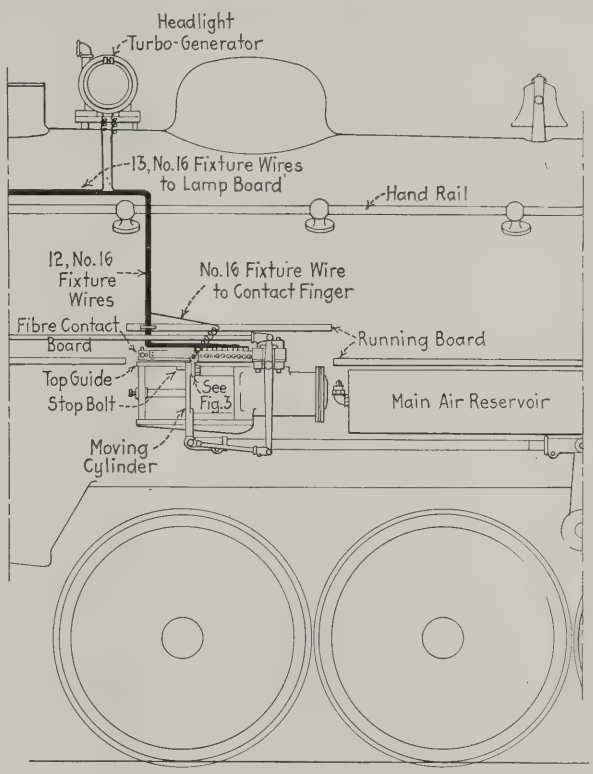


Fig. 1.—Wiring and Contact Arrangement at Contact Board on Moving Cylinder Type Reverse Gear

gear being tested was of the moving piston type the contact finger was mounted on a bracket fastened to the piston crosshead. As the forward motion was the only portion of the travel which the tests concerned, an insulating strip flush with the tops of the contact buttons was mounted so that the contact finger could travel over the entire motion of the gear without danger of sticking. It was found necessary to slot the fibre contact board at each point of support in order that an adjustment might be made to compensate for the expansion of the boiler. Then when the engine was "hot" the apparatus was set so that the first or "corner" button was exactly under the contact finger when the reverse gear was in the corner position for forward motion. It is interesting to note here that the error due to expansion was found to be approximately one notch if the fibre board was

mounted rigidly when the engine was cold and not adjusted after the engine was hot.

The indicating device used in the dynamometer car and shown in Fig. 2, consists primarily of a light for each position of the gear when in the forward motion.

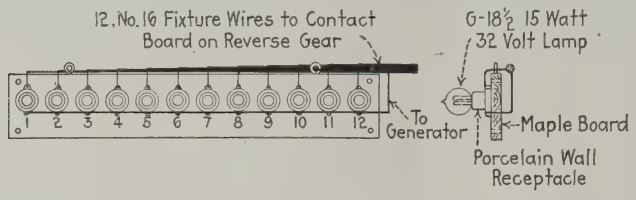

12, No. 16 Fixture Wires to Contact Board on Reverse Gear
6-18½ 15 Watt 32 Volt Lamp
1 2 3 4 5 6 7 8 9 10 11 12
To Generator
Maple Board
Porcelain Wall Receptacle

Fig. 2.—Cutoff Indicator Lamp Board

For this purpose porcelain wall receptacles were mounted on a maple board of suitable dimensions, and the board was arranged so that it might either be secured to the wall with screws or suspended from screw eyes at two points. The lights used were the railway company's standard 15 watt, 32 volt cab lights

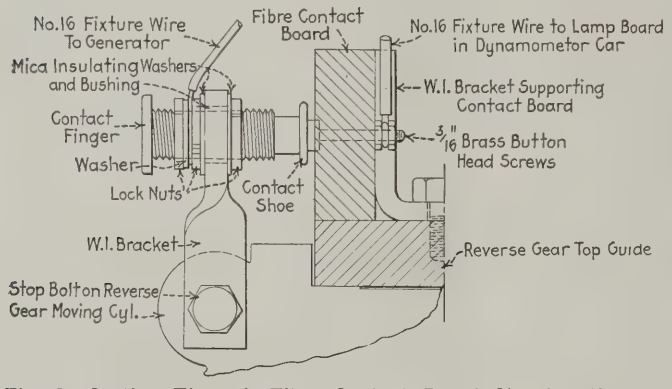

No. 16 Fixture Wire To Generator
Fibre Contact Board
No. 16 Fixture Wire to Lamp Board in Dynamometer Car
Mica Insulating Washers and Bushing
W. I. Bracket Supporting Contact Board
Contact Finger
3/16" Brass Button Head Screws
Washer
Lock Nuts
Contact Shoe
W. I. Bracket
Reverse Gear Top Guide
Stop Bolt on Reverse Gear Moving Cyl.

Fig. 3.—Section Through Fibre Contact Board Showing the Arrangement of the Contact Finger and Contact Buttons.

and current was supplied from the headlight turbo-generator, as shown in Fig. 1. The number under each light indicates the number of the contact button with which it is in series and therefore the position of the gear when that particular circuit is closed by the contact finger. The figures are of sufficient size that they may be easily seen from any point in the dynamometer car. The wiring arrangement for this device needs no further explanation than to say that the bundle of wires extending from the reverse gear to the indicator was composed of 13-No. 16 fixture wires laced together and suspended from hooks on the locomotive and tender tank, each end of each wire being fitted with a No. 6 copper terminal stamped with the contact number corresponding to the reverse gear position which its lamp indicated.

The arrangement of the contact finger and its supporting bracket is shown in Fig. 3. The diameters of the contact finger and contact buttons were made such that when the finger was at the half way point between two buttons both buttons would be slightly overlapped by the finger and two lights on the indicator board would light. This result was obtained by brazing a circular copper shoe on the end of a controller contact finger of standard design. With this arrangement it was found that every movement of the gear could be easily followed on the lights.

When the engine had been calibrated so that the per cent cutoff was known for each position of the gear it was possible to make an accurate study of the automatic control. Likewise it became possible for the observers in the dynamometer car to direct the "notching up" when the automatic feature was not being used and to detect creep when the test was being made on a locomotive equipped with a piston type reverse gear. Consequently, although the electric cutoff indicator has practically no value except for test purposes, it may be found to be of great value when put to that use.

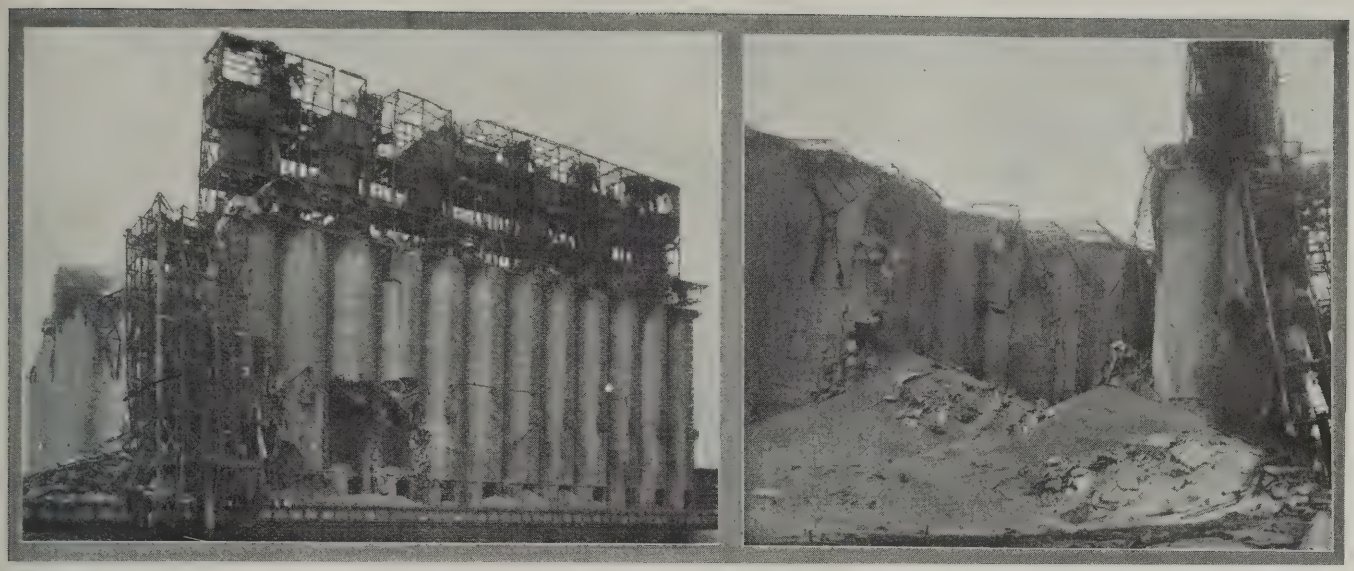
The Annual Report of the relief department of the Chicago, Burlington & Quincy shows that during the year 1920 the department paid $627,148 in sick and death benefits. Employees contributed $678,817, income from investments was $20,625 and interest on cash advanced by the railroad was $7,013. There was an excess of receipts over disbursements of $65,279.

Photo by International

The Railway Line Which Intersects the Great Chinese Wall

Photo by International

American Cars Unloaded at Danzig, Poland, Ready to be Assembled

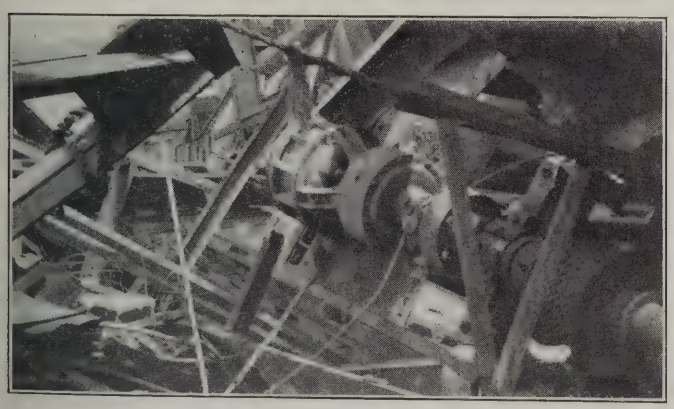


The River House and a Broken Corner of the Storage House

Effects of Dust Explosion on C. & N. W. Grain Elevator

Switch-Board Apparatus Partly Destroyed. Many Motor Frames Broken, But Cable Runs Are Fairly Intact

AN extensive salvaging program is being carried on by the electrical department of the Chicago & North Western in recovering the electrical equipment of the Calumet grain elevator which was destroyed by a dust explosion on March 19. The structure was leased and operated by the Armour Grain Company, and was one of the largest plants of its kind in the world.



One of the Motors Used for Unloading Grain From the Cars

It represented an investment of about $10,000,000, was composed of a storage house, a work house and a river house, each consisting essentially of concrete bins of the usual construction with a storage capacity of 6,000,000 bushels surmounted by superstructures or galleries and cupolas, which in the case of the work house and the river house extended to a height of approximately 200 ft. above the track level. The work house which consisted of 95 bins was flanked on the west by a track shed accommodating cars on five tracks and surmounted in part by a dryer, a large rectangular structure, having a structural steel frame covered by walls of re-enforced stucco or "gunite." The walls of the cupolas and galleries above the bins were composed of the same material, while the roofs consisted of thin concrete slabs covered with a suitable roofing.

All evidence indicates that the dust explosion consisted of the progressive ignition of an explosive mixture of dust and air, filling practically all of the enclosed spacings in the structure which were not occupied by the grain. The greatest intensity of the explosion was apparently in the two cupolas over the work house and river house, respectively, and in the gallery over the storage bins, the effects being to burst off all of the gunite walls and concrete roofing from the steel frames, which were left in a more or less distorted and otherwise damaged condition. The fragments of wall and roofing constructions were blown to great distances from the elevator, and this material, falling from a great height on the roofs of the power plant, office buildings, and other auxiliary structures, crushed in their roofs and otherwise seriously damaged them.

The dryer structure was torn from its support against the side of the work house bins and fell on the track shed, which was completely wrecked, crushing twenty cars which were in the shed at the time, or causing them to be thrown into the pit or track hopper below the tracks.

Damage to Electrical Apparatus

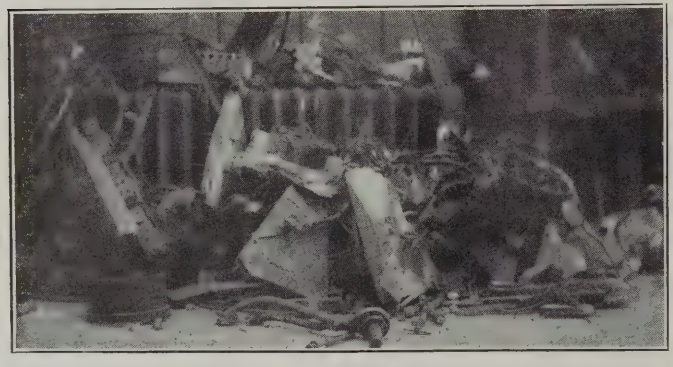
All of the machinery in the elevator was operated by individual drive motors operating on 550 volts, 3 phase, 60 cycle alternating current. The machines used for unloading the grain from the cars were operated by 7½ hp. motors, all of which were carried down in the wreckage of the track shed. Two of these motors were ruined by fire and the frames of several others were broken. The motors have been dismantled and the frames are be-

ing readily repaired by the electric arc welding process.

The 50 hp. fan motor, shown in one of the illustrations, was thrown with its concrete base and the fan which it operated about 75 ft. clear of the building. The motor was not injured except that the shaft was bent between the motor and the fan. Some of the conveyor motors have small pieces broken out of the frames but are otherwise in good condition. Practically all of the larger motors used for elevating the grain were unharmed by the explosion. One of the compensators will require a new oil container and several new contacts.

A Large Fan Motor Together With Its Concrete Foundation Was Thrown Out 75 Feet Clear of the Building. The Motor Was Not Injured Except that the Shaft Was Bent Between the Fan and the Motor.

The signaling system, consisting of an arrangement of colored lights electrically controlled, went down in the wreckage. The junction boxes, switches and three unit light signals will have to be replaced. The main feeder cables running in conduits from the power house to the head house are practically unharmed. Many of the lighting circuits and minor power feeders will be replaced completely.



Some of the Apparatus on the Power House Switchboard Was Damaged Beyond Repair

The Power House

The roof of the power house, including the girder supports, was torn down by the weight of falling concrete. The traveling crane happened to be in a position to protect one of the generators.

The bench type switchboard had one corner panel broken off and about half of the meters smashed. One of the field rheostats with the attached switching gear was demolished beyond repair. The lead type storage battery housed in a separate room on the balcony was not harmed, and as it was fully charged at the time of the accident, was employed to good advantage for emergency lighting service. The telephone switchboard was ruined beyond repair.

The generating equipment consists of two 2,300kva., 3 phase, 600 volt, 60 cycle turbo-generators and one kva. 3 phase, 600 volt, 60 cycle turbo-generator. The end bell of one of the large generators was smashed. The dash pot governor equipment was damaged on the small generator. The field exciting equipment, located under the balcony, was unharmed.

The first work of reconstruction in the power house was to get large generator No. 2 in shape for operation. The switchboard panel for No. 1 and the field rheostat for No. 3 being connected up for this generator. The boilers were not harmed, but a small piece was broken out of the top of the brick smoke stack.

One Corner of the Bench Type Switchboard Was Broken

Two large blowers, operated by 500 hp. motors, have been set up and this equipment is being used to load all of the grain in the elevators into cars. It will be necessary to dispose of all of the grain before the bulk of the reconstruction work can be done.

Photo by Ewing Galloway, N. Y.

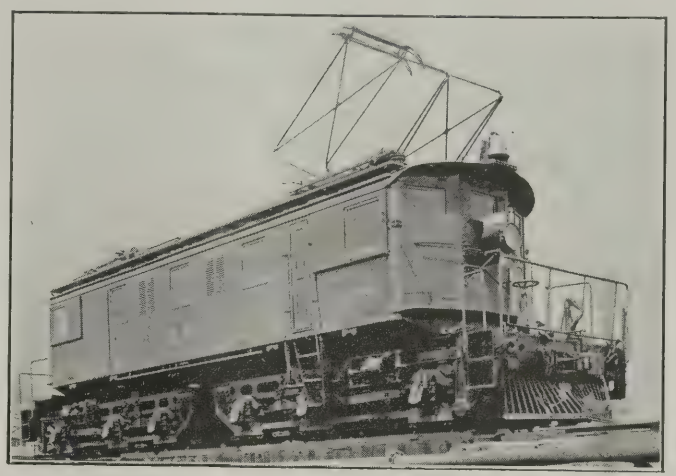
Piers and Freight Yards at Cleveland, Ohio; with Union Station Train Shed in Foreground

Headlight Wiring on the Canadian National

THE Canadian National Railways standard locomotive wiring plans, which are shown in the illustrations, are designed to afford permanence and reliability in this connection.

The insulated wires to the headlight run from the terminal box through the handrail to the headlight, classification lights, number light, and snow plough connection. Where headlight is equipped with pilot light socket, as shown in Fig. 1, it should be wired in multiple with snow plough circuit.

Wires to the tail light, tender marker lights and water funnel light, run in conduit from the terminal box back through the switches in cab, thence through a loose steel flexible conduit used between locomotive and tender (this being fitted with a 3-point plug which connects, into a receptacle, allowing the locomotive and tender to be disconnected without the necessity of severing the wires), and thence through the handrail on the tender. Condulets are fitted at the required places, to permit the various lights on the tender to be applied. The lights in the cab are capable of being detached at any time, without interfering with the permanent conduit work. Benjamin



Freight Locomotive for the Paulista Railway

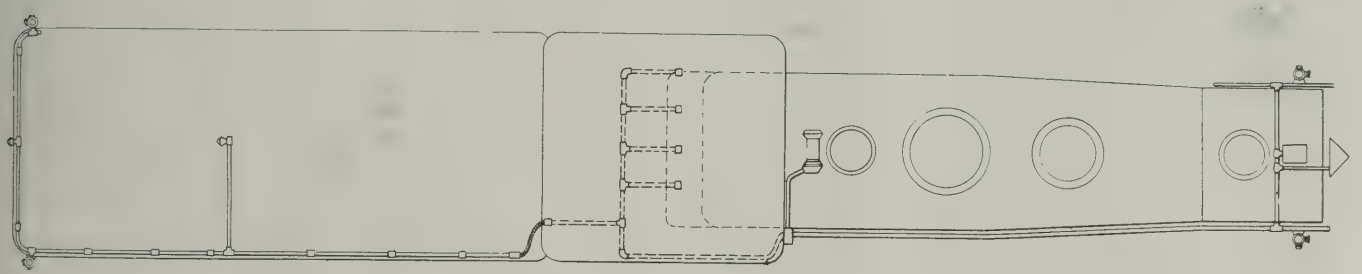


Fig. 1—Sketch Showing Arrangement of Conduit Runs on the Locomotive and Tender

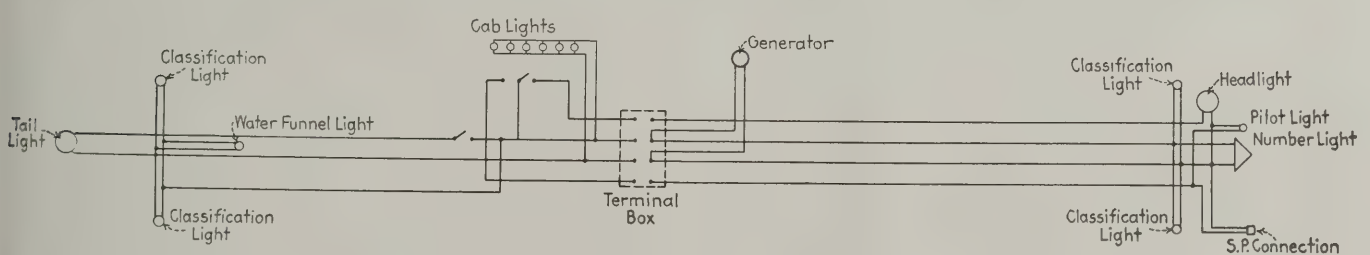


Fig. 2—Wiring Diagram for Locomotive Headlights and Cab Wiring

903G plugs are used for this purpose, with steel flexible conduit and asbestos covered cord.

In practically all of the locomotive headlights, 250 watt nitrogen bulbs are used, in place of the arc light which was formerly standard with locomotive electric lighting equipment.

Electric Locomotives for South America

THE first Baldwin-Westinghouse freight locomotive for the Paulista Railway Company, Brazil, S. A., has been completed and tested. The passenger locomotives are nearing completion. Announcement of the proposed electrification of the Paulista Railway was made in the May, 1920, issue of the *Railway Electrical Engineer*.

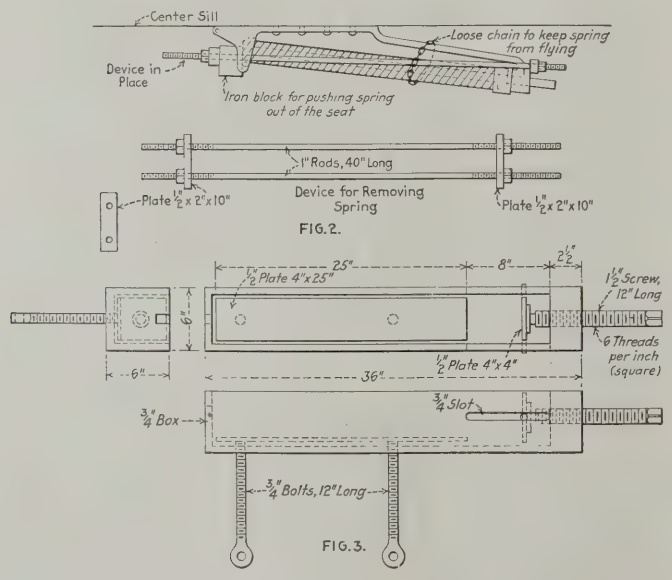
The locomotives are to be used in freight service on the principal broad gage trunk lines of the railroad which runs through the most prosperous and productive part of the state of Sao Paulo. The freight locomotives each weigh 116 tons and have six driving axles, each equipped with one 280 hp. direct-current motor, arranged for operation with two motors in series on the 3,000-volt line. They are designed to handle trailing loads up to 770 tons over a line having a maximum grade of about 2 per cent. The locomotives are equipped with M. C. B. couplers for testing purposes, but will later be equipped with continental draft gear and arranged for vacuum train brakes.

Twelve hundred and fifty calls in 24 hours is the record recently made on one train dispatcher's telephone circuit, as reported by W. P. Cline, superintendent of telegraph of the Atlantic Coast Line. This is equal to over fifty calls an hour, and illustrates in a striking way one of the advantages of the telephone for sending train orders. The statement was made in a brief address before the last meeting of the Southern & Southwestern Railway Club, at Atlanta, on the use of the telephone in train dispatching. Mr. Cline is satisfied that by the operations, marked benefits not only result to the general conduct of train movement on his division, but he also does his work with less nervous strain and less fatigue, which, of course, makes for increased efficiency.

Removing and Applying the Spring of a Belt Tension Device

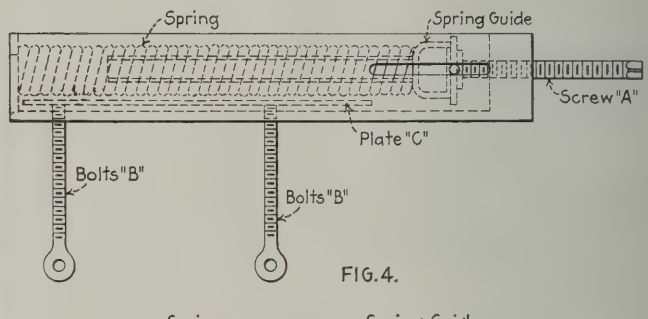
The belt tension device shown in Fig. 1 is equipped with a very heavy spring which must be compressed before it can be either removed or replaced in the bracket. This spring is made of ¾-in. material and has a solid load of approximately 5,000 lb. It is often necessary in making repairs to this tension device to remove the spring and later apply it again to the bracket. Without the aid of some device for the purpose of compressing this large steel spring it would be a very difficult matter either to remove or reapply it.

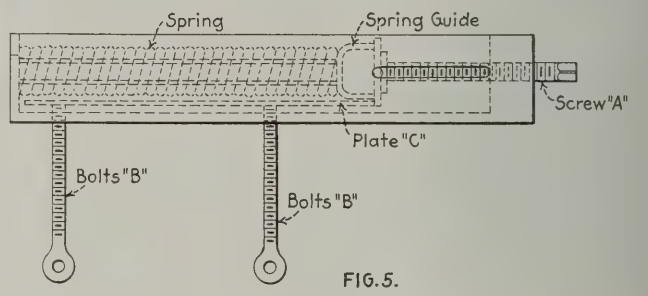
Fig. 1—Showing Arrangement of Spring and Bracket

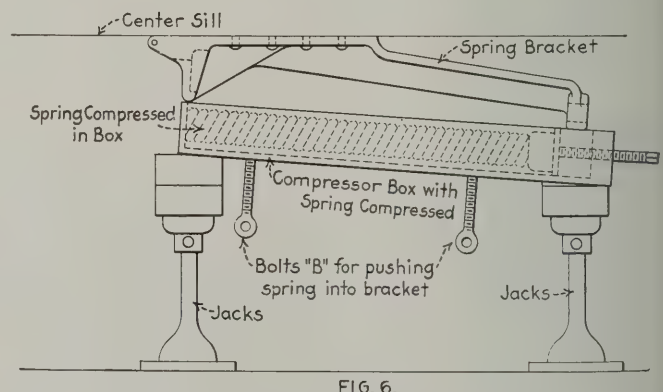


Figs. 2 and 3—Showing Devices Used for Removing and Replacing the Spring

A device for removing such a spring is shown in Fig. 2. It consists of two steel plates, two steel rods, and a small iron block. In applying the device the tension wheel shown in the photograph is removed and the device is clamped over the bracket as indicated in the upper part of Fig. 2. In compressing the clamp the small iron block presses the end of the spring clear of the spring seat. As it would be a dangerous matter for anyone to be close to the spring when the tension was released on account of







Figs. 4, 5 and 6—Showing the Various Steps Taken In Putting the Spring Back in the Bracket

the great amount of energy stored in it, a small chain is placed loosely around the bracket to keep the spring from flying, and after a bar has been inserted between the bracket and the spring, the latter may be pried out with safety.

In applying the spring to the bracket again another device quite different from the one used in removing it is most essential as it would be impossible to compress the spring to the required amount by any ordinary means. The device for applying the spring is shown in Fig. 3. It consists of a steel box, compressor screw, steel plate, and two eye bolts. It will be noticed from the diagram of Fig. 3 that the plate at the end of the compressor screw is so constructed as to slide along in slots cut in either side of the steel box. This makes it impossible for the plate at the end of the compressor screw to move in any other than a lengthwise direction regardless of whatever tendency the compressed spring might have upon it.

In replacing the spring in the bracket, the spring in its fully extended condition is placed in the box and its compression is begun by turning the screw "A." Fig. 4 illustrates this stage of the replacement and shows the spring partly compressed. Fig. 5 shows the spring fully compressed, ready to be replaced in the bracket.

The final step consists of placing the box against the spring bracket and holding it firmly in place with two jacks as shown in Fig. 6. Then by turning the eye bolts "B", the bottom plate "C" pushes the spring and spring guide into the bracket. This method has been found to have a number of advantages over other methods, particularly that it is safe and consumes less time.

Using a Magneto in a Noisy Shop

By E. R. Chinberg

The electrician on a steam railroad very often finds it necessary to test for grounds on electrical equipment in places which are habitually noisy. This is especially true in the case of the electrician maintaining electric

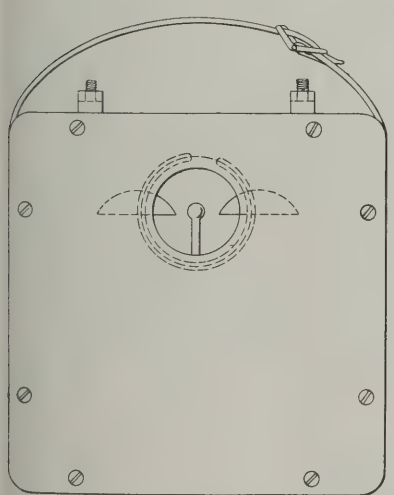


FIG. A.

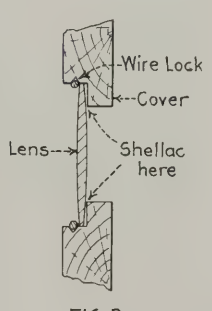


FIG. B.

Construction Details for Making a Magneto Suitable for Visual, as Well as for Audible Testing

headlights, as it is necessary for him to make this test in the roundhouse. On account of the dirt and grease around a railroad, a magneto totally enclosed is usually selected as a standard, and this makes it necessary to depend on the hearing alone when "ringing for grounds." Due to the noise, it is sometimes very difficult for the electrician to determine whether he has a ground or not, especially if it is a slight one.

To enable the electrician to use his sight as well as hearing when "ringing for grounds," the following stunt has been found to be of great benefit, as it enables the electrician to see the clapper when making the test. If the place in which he is working is noisy, he can see the clapper striking the bells and know positively that he has a ground without wasting time trying to hear the sound of the bells.

To prepare a magneto for use in this manner, first get a lens from a safety goggle. These are very hard to break, and consequently well suited for this purpose. Next, remove the cover from the magneto, and on the inside of the cover at a point which comes directly over the clapper and bells, start a hole with an extension bit the size of the lens. This hole should not go through the cover—in most cases a cut the depth of the lip on the bit will be sufficient. Then reduce the size of the bit one-half inch in diameter and bore the hole through the cover. With a knife remove the wood to the depth of the cut made by the lip of the bit when starting the larger hole. This will form a sharp shoulder. Now place the lens in position and with the knife, cut a little groove in the wall of the hole just above the lens. A short piece of spring brass wire put in the groove will lock the lens in place and yet permit quick replacement in case of breakage. Before the lens and wire lock are permanently applied, the lens should be seated in thick shellac, which will make the cover dustproof and also serve to support the lens.

Referring to the sketch, Fig. A shows how the bells and clapper appear when the lens is properly placed, and Fig. B illustrates a cross section of the cover, showing the shoulder in the cover, lens and wire lock.

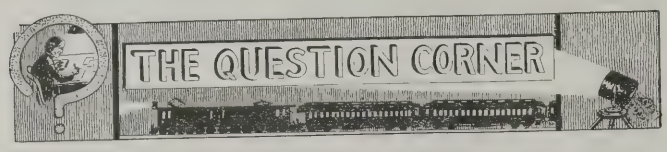
Use Grease for Cleaning Reflectors

From various sources the suggestion has come recently that the best way to clean reflectors and the front glass of floodlights or headlights used for lighting enginehouses is to use hard or Albany grease. The grease is simply smeared over the surface to be cleaned and wiped off with a cloth. The result is a surprisingly clean surface and a surface which will remain so longer than one cleaned by almost any other method. The grease also serves to protect the metal of the fixture from corrosion.

Upon the face of it, this seems like a peculiar suggestion, but with a little consideration it is not difficult to understand. About the best thing to remove tar from the hands is butter, or some similar form of grease. This cuts the tar which then can be washed off with soap and water. The coating which forms on surfaces in the enginehouse is largely a coal tar product, which also requires grease to cut it. The reason that the grease-cleaned surfaces remain clean so long as they do is probably due to this same aversion which the grease has to coal tar.

Educational processions that side-step prejudices met on the road to Knowledge, never reach the desired goal.

The degree of friendship of one man for another is determined by the number and strength of their prejudices.



Answers to Last Month's Questions

1. *How would a U. S. L. 100-ampere generator, 153 type panel work with battery connected up wrong, that is, positive lead to negative side of battery, and negative to positive side of battery?*

2. *Would your generator reverse itself and other parts of your equipment, that is, would the positive turn negative and the negative turn positive?*

3. *Would your meter read reversed?* *J. A. R.*

* * *

In answer to J. A. R.'s questions regarding reversed battery leads on 100 ampere generator I would say,

1. That the main generator fuse would blow because generator current would add to the battery current.

2. No parts of the equipment would be reversed except battery leads.

3. Meter would read reversed due to reversed leads. H. H.

* * *

1.—If the battery were in a fully charged condition, the generator would build up with correct polarity. When the voltage reached 32.5 the automatic switch would close, connecting the positive side of the generator to the negative side of the battery. The instant the automatic switch closed there would be an excessive rush of current through the main battery circuits in the direction indicated by the arrows in the diagram. The current rushing through the series regulating solenoid would raise the generator regulating arm to its extreme upward limit of travel and then the generator fuse

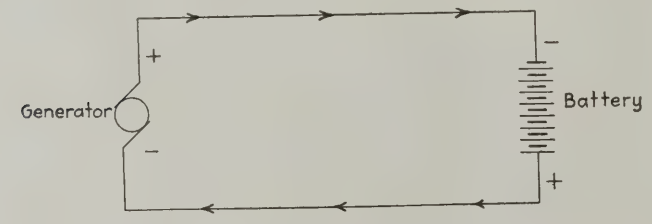


Diagram Showing How An Excessive Rush of Current Would Occur Due to Generator and Battery Being in Series

would blow. The battery will then furnish the current to the lamps.

2.—If the battery were in a discharged condition the generator would build up with correct polarity as before, the automatic switch would close at 32.5 volts and the battery would be charged in a reverse direction. This charging in a reverse direction would change the negative plates of the battery to positives and the positive plates to negatives. The battery would not have its original capacity or efficiency in this direction, but after a few cycles it will deliver over 50 per cent of its original capacity. The generator and other parts of the equipment would not reverse.

3.—In case the battery was fully charged, the current from the battery to the lamps would operate the meter in a charge, instead of a discharge, direction. The heavy rush of current when the automatic switch closed would operate the meter in the charge direction also. After the generator fuse has blown, the current from the battery to the lamps would still operate the meter in the charge direction.

In case the battery was exhausted, the current from the generator to the battery would operate the meter in a charge direction, and after the battery was charged and the car standing the current from the battery to the lamps would operate the meter in a discharge direction. In other words, in this case, the meter would operate in the same direction as if the battery leads were connected correctly. C. S.

* * *

While reading the *Railway Electrical Engineer* of April it was a pleasure to find therein a question pertaining to car lighting, and I hope in the future to see more questions on this same subject.

In answering J. A. R., would say that I am not familiar with the type 153 panel, but have reason to believe that all U. S. L. equipment operates on the same principle. The following is a brief outline of what I believe would happen:

By connecting the positive side of the line with the negative side of the battery and vice versa, it would reverse the direction of current throughout the entire system.

The lamp regulator, which is generally connected on the negative side, would then be on the positive side.

The generator would work O. K., and charge the battery in the proper direction.

The ampere-hour meter would register in the reverse direction, that is, with the battery on charge it would show discharge, and with the battery on discharge it would show charge.—W. McG.

* * *

I believe the following are the correct answers to your April problems. A U. S. L. generator being shunt wound will reverse, if the field gets current from the battery; the positive will turn negative and the negative will turn positive, and so will charge the battery O. K. The meter, however, will read reverse. In answering the questions by number, they would appear as follows:

1. Generator will work O. K.
2. Generator will reverse itself.
3. Meter will read reverse. A. H. M.

* * *

Questions For May

1. *Why is it that manufacturers of lead storage batteries insist upon the use of distilled water in flushing the cells?*

2. *Two sets of batteries on the same train were flushed on the same date, but at the end of a month one set is down to the top of the plates, while the other set is still good for two weeks. The lamp load is the same for both batteries, which set would be considered in normal condition?*

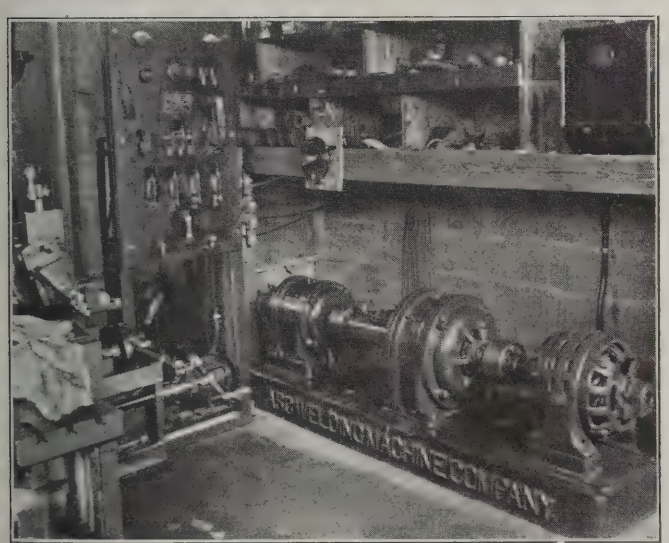
3. *If no fuses are blown and the belt is O.K. on an axle generator equipment that is not working what is the first test to be made to locate the trouble?* *A. R. E.*

Send your answers to the Editor.

NEW DEVICES

Constant Current, Single-Arc Welding Machine

A single-arc welding machine has been developed by the Arc Welding Machine Company, New York, which operates on the same principle as the multiple-arc unit manufactured by this company. The characteristics of two types of machines are practically identical. The welding current is maintained constant at any particular setting, but the arc voltage is limited. The electrode holder is nominally dead, except when the trigger on the handle is pressed by the welder. This gives the welder a greater control of the arc, eliminating the possibility of accidental flashes and also making it possible for the welder to place his elec-



Welding Outfit Installed in a Repair Shop

trode at the point where he desires to start his weld before puuting his mask over his eyes.

The outfit consists of a motor generator set with an arc control panel. The generator set furnishes a constant current in the welding circuit at any value from 25 to 200 amperes. The generator field excitation is furnished by a regulator of special design. The regulator is differentially wound with the separate excitation opposing the series excitation, which carries the welding line current. The welding line current or arc current is automatically maintained constant by this regulator and may be adjusted over the entire range of the machine. The arc control panel furnishes means for adjusting the arc, permitting any desired value of welding current, within range of the machine to be obtained, by adjusting the field rheostat of the regulator, which is mounted on this panel. A smaller rheostat is also provided which controls the arc voltage limit, thereby permitting a variation of the arc voltage limit to meet the particular requirements of the work. Knife switches provide means for obtaining maximum stability of arc and at the same time permit a minimum expenditure of power.

Equipment is supplied for any standard alternating or direct current voltages. It is primarily intended for stationary installations, but can also be furnished mounted on a truck for portable use. The weight of the entire outfit ready for use is approximately 2,000 lb.

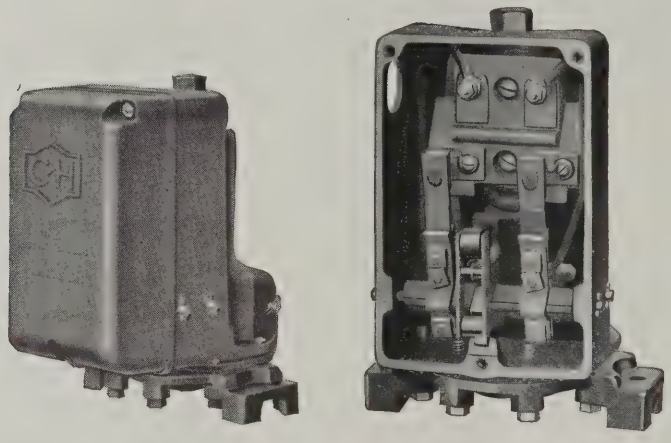
Pressure-Operated Switch of Compact Design

A small pressure regulator of the diaphragm type has recently been developed by the Cutler-Hammer Manufacting Company, Milwaukee, Wis. It is designed for use with motor-driven pumps and compressors operating on closed pressure systems. The switch automatically starts and stops the pump or compressor at such times as the pressure falls or rises to a predetermined minimum or maximum pressure, thus maintaining the pressure between two fixed limits. It is commonly used with motors controlled by a main line magnet switch or some other suitable automatic starting device. It has two poles, which also makes it possible for use with small A. C. and D. C. motors connected directly to the line. The overall dimensions of the device are 6 in. x 6½ in. x 8 in.

The air, water, or other fluid under pressure is conducted into a chamber in the base of the regulator, and the pressure acts against a rubber diaphragm and compresses a spiral spring, the normal compression of which can be changed by means of an adjusting nut to obtain various values of opening pressures up to 60 lbs. per sq. in. When the switch is closed and the pump or com-

pressor operating, the pressure builds up, and when the adjusting spring has been compressed to a certain point, the switch snaps open and stops the motor. When the pressure has fallen to a predetermined point, the switch closes with a quick action, and the pump or compressor again operates to build up the pressure system.

This quick make-and-break action of the switch is accomplished by an arm carrying a roller which is held in tension against a cam mounted on the operating shaft of the switch. The movement of the adjusting spring is transmitted to the roller which moves along the surface of the cam. When the opening or closing pressure is reached, the roller passes a peak on the cam, and gives



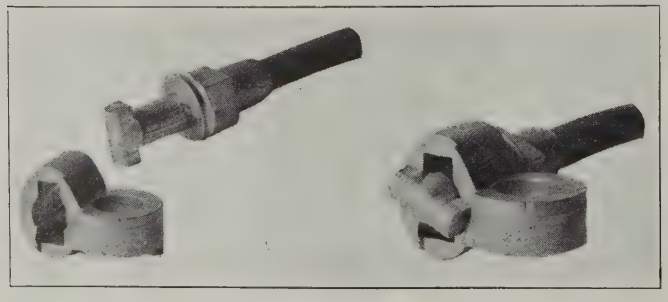
Bulletin 10004 Pressure Operated Switch With and Without Cover

the latter a quick turn, thereby opening or closing the switch. A good contact pressure is maintained up to the instant the switch is opened. The difference between opening and closing pressures is about 20 lbs.

The entire mechanism of the regulator is enclosed in a cast iron case arranged for the entrance of conduit. Terminals and fingers are exposed by taking off the cover of the case, which necessitates only the removal of three screws. The regulators are at present made for 60 lbs. maximum service, and it is expected that they will shortly be provided for use on systems up to 200 lbs. pressure with few slight modifications in design.

An All-Lead Battery Connector

A battery connector made entirely of lead, without any screw or bolt made of brass or some hard metal, has been developed by Frasier & Marsh, Devon, Conn.



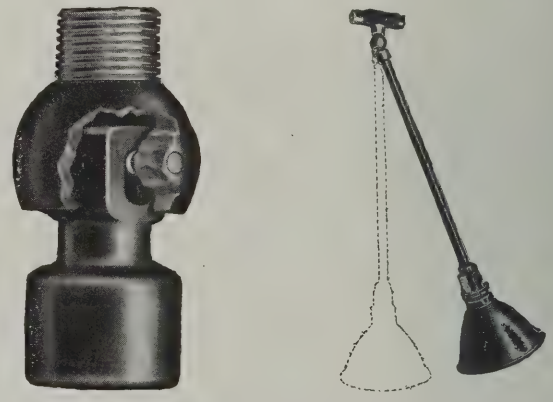
Photograph Showing Method of Joining Connector

The two parts of the connector are shown at the left of the illustration. The ring or loop is slipped down over the battery post and burned on. The edges of the metal on either side of the rectangular hole are beveled from top to bottom and from bottom to top respectively, with a five-degree pitch.

To make the connection, the T-shaped part on the end of the wire is pushed through the rectangular hole and given about a quarter turn. This causes the under side of the T to slide up on the beveled edges and pull the connector into the hole until it draws tight. To avoid twisting of the cable, the part of the connector which is burned on to the battery post is furnished with both right and left-hand bevels. The advantages claimed for the connector are that it will not corrode, there are no parts to become lost, that it can be connected or disconnected quickly and as a soft metal is used, it freezes together and will not vibrate loose. If a part becomes burned by accidental arcing, a slight tap or application of a jack-knife puts the part in service again. The connectors are made in a variety of sizes.

Flexible Fixture Joints

A new type of condulet known as the UNJ condulet fixture joint has been developed by the Crouse-Hinds Company, Syracuse, N. Y. The device is designed for supporting suspended type fixtures and can be used in conjunction with condulets, in which the joint shown in the illustrations supports the fixture and the condulet provides a separate wiring chamber for the connection. The universal joint assures that the fixture,



Details of Construction and Application of Flexible Fixture Joint

even though mounted on an inclined surface, will hang plumb. This is of particular importance where there are a number of fixtures hung in a row and it is desired that all hang vertically.

Breakage of the supporting conduits or condulets is minimized by the flexibility afforded by this joint. Strains caused by the wind or a bump from a step ladder are not as liable to cause damage as with a rigid fitting, and the support is not so apt to be damaged when the fixture is being cleaned as is sometimes the case where the fixture is immovable.

The construction is such that the wires pass through the joint, and consequently no wires are exposed. The fixture joint will allow the fixture to swing through an angle of 20 deg. in any direction from the perpendicular.

General News Section

The Chicago Fuse Company announces the removal of its New York office to new and larger quarters located in the Tilden Building, 105 West 40th street.

The Stone Franklin Company removed its general offices on April 20 from 30 Church street to the National City building, 17 East Forty-second street, New York City.

Rickard & Sloan, New York, specialists in industrial and technical advertising, announce a change in corporate name. In the future the firm will be known as Rickard & Co., Inc.

A wireless station is to be constructed at a point near Pisa, Italy, for the purpose of establishing regular communication with the United States. Work will be begun early in 1922.

The National Electric Light Association will hold its forty-fourth convention in the new Drake Hotel, overlooking Lake Michigan, in Chicago, May 31 to June 3, inclusive. The convention will open Tuesday morning, May 31, at 10 o'clock and will close the following Friday evening.

The United States Civil Service Commission has announced an open competitive examination for shop apprentices. Vacancies in the Bureau of Standards at $720 a year and positions requiring similar qualifications will be filled from this examination. Applications will be received by the commission at Washington, until August 1, 1921.

The Long Island Railroad expects to electrify its division between Valley Stream and Babylon as soon as financial conditions will permit, according to a statement made by P. H. Woodward, general passenger agent, at a meeting of the Community Association of Bayshore on April 11. The distance from Valley Stream to Babylon is 21 miles.

Sidney G. Johnson, formerly vice-president and general sales manager of the General Railway Signal Company, has been appointed eastern sales representative for the Hazard Manufacturing Company to look after its interests in rubber insulated railroad signal wire and kindred products, with the railroads in eastern territory. Mr. Johnson's headquarters are located in room 626, 30 Church street, New York City.

Ninety miles in one hour and twenty minutes was the time which was recently made by a special train of two cars from Philadelphia to Jersey City over the Philadelphia & Reading and the Central of New Jersey, a speed equal to 67.5 miles an hour. This train was run for J. L. Stokes, a banker, to enable him to connect with a train for Montreal, the Pennsylvania being blocked by a derailment and the Reading having no regular train for two hours. Mr. Stokes paid for the train $427.

According to reports from Switzerland during the next few weeks a commission of foreign engineers will visit Switzerland for the purpose of studying the electrification of the Swiss railroads. The commission will be composed of three American and three Swedish engineers. Mr. Oefverholmen, the Director General of the Swedish State Railways, heads the commission. The foreign engineers will inspect the Gotthard and Lotschberg lines and the large new power stations on both of these lines.

The following officers of the American Welding Society were elected on April 28, 1921, at the annual meeting of that society: president, S. W. Miller, Rochester Welding Works; vice-president for two years, C. A. McCune, Page Steel & Wire Company; directors for three years, A. S. Kinsey, Stevens Institute of Technology, E. M. T. Ryder, Third Avenue Railway Company, E. Wanamaker, Chicago, Rock Island & Pacific Railroad, J. C. Lincoln, Lincoln Electric Company, W. T. Bonner, New York Shipbuilding Company, H. R. Swartley, Davis Bournonville Company, D. B. Rushmore, General Electric Company, H. L. Nicholson, Westinghouse Air Brake Company.

Electrification in Zanzibar

Along with extensive improvements to Zanzibar Harbor, extending over the next three years, one of the projects mentioned is a narrow-gage electric railway to run the length of the island, according to Guaranty Trust Company.

Illuminating Engineering Society Convention in September

The annual convention of the Illuminating Engineering Society will be held in Rochester, N. Y., during the week of September 26, 1921. Robert M. Searle, vice-president of the Rochester Gas & Electric Corporation, has been appointed chairman of the general committee for the convention.

Mechanical Engineers to Discuss Power Resources of the Middle West

The power session at the spring meeting of the American Society of Mechanical Engineers will be devoted to the subject of "Power Resources of the Middle West." Samuel Insull, president of the Commonwealth Edison Company, will preside at the session which will be held at the Congress Hotel, Chicago, Ill., on Thursday, May 26, at 10:00 a.m.

Two papers will be presented. One by W. L. Abbott, chief operating engineer of the Commonwealth Edison

Company, will show the situation at the present time regarding power development and interconnection of power systems. The second paper will be presented by C. W. Place of the General Electric Company, and will describe the power resources of the Middle West district so far as water power is concerned, giving the location, amounts and possible developments of these resources.

St. Paul Employees to Acquire Stock

Employees of the Chicago, Milwaukee & St. Paul have started a movement to acquire stock in the company. At a recent informal dinner of the employees of the auditor's office, 189 employees subscribed for 379 shares of the stock. They formed the "Action Club" and each employee owning a share of stock will wear a button on which will be inscribed, "I Am An Employee Stockholder." When the subject was discussed at the dinner the clerk who proposed the purchase of stock by employees said the company offered nothing and that officers of the road were in no way back of the proposition. Arrangements will be made to purchase the stock through brokers and payment will be made on the installment plan.

Program of the A. I. E. E. Annual Convention

The tentative program of the annual convention of the American Institute of Electrical Engineers to be held at Salt Lake City, Utah, June 21 to 24, inclusive, has been announced as follows:

TUESDAY, JUNE 21

President's address, by Arthur W. Berresford; technical committee reports; "Hydro-Electric Developments at Niagara Falls," by J. L. Harper, Niagara Falls Power Company; "Modern Developments in Waterwheels," by W. M. White, Allis-Chalmers Company.

WEDNESDAY, JUNE 22

"Economic and Engineering Problems of the 220-Kv. Transmission," by L. E. Imlay, Superpower Survey, New York; "Voltage and Power-Factor Control of 66,000-Volt Transmission Lines Connecting Two Generating Stations," by Raymond Bailey, Philadelphia Electric Company; symposium on long-distance transmission systems, by F. G. Baum, consulting hydro-electric engineer, San Francisco; W. W. Lewis, General Electric Company, Schenectady, N. Y., and L. L. Elden, Edison Electric Illuminating Company of Boston; "Modern Production of Suspension Insulators," by E. H. Fritz, Pittsburgh High-Voltage Insulator Company, and G. I. Gilchrest, Westinghouse Electric & Manufacturing Company.

THURSDAY, JUNE 23

"Voltage and Current Harmonics Caused by Corona," by F. W. Peek, Jr., General Electric Company, Pittsfield, Mass.; "A Solution of the Porcelain Insulator Problem," by E. E. F. Creighton, General Electric Company, Schenectady, N. Y., and F. L. Hunt, Turner's Falls Power & Electric Company; "Transformers for Interconnecting High-Voltage Systems or for Feeding Synchronous Condensers from a Tertiary Winding," by J. F. Peters and M. E. Skinner, both of Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.; "Electric Strength of Air Under Continuous Potentials and as Influenced by Temperature," by J. B. Whitehead and F. W. Lee, both of Johns Hopkins University, Baltimore.

FRIDAY, JUNE 24

"Synchronous Motors for Ship Propulsion," by E. S. Henningsen, General Electric Company, Schenectady, N. Y.; "Magnetic Properties of Compressed Powdered Iron," by Buckner Speed and G. W. Elmen, both of Western Electric Company, New York; "Heat Losses in Conductors in Alternating-Current Machines," by W. V. Lyon, Massachusetts Institute of Technology.

General Electric Company Enlarges Fort Wayne Works

The General Electric Company has purchased 60 acres of ground for the expansion of its Fort Wayne works, the land joining the present property of the company. The erection of new buildings on this land, which will increase the plant about ten per cent, is to begin shortly. It is the intention of the company to put up two large one-story buildings of 65,000 sq. ft. floor space each. The transformer shop of the plant will occupy these new buildings. At the present time the company occupies a total floor space of 1,300,000 sq. ft. and according to company officials the new property is big enough to provide space for doubling the size of the present plant. About 6,000 workers are engaged at the Fort Wayne works now and when the additional buildings have been erected it is expected that at least 500 more will be employed.

Electrification of Latvian Railway

A group of foreign capitalists has begun negotiations with the town council of the Riga Strand and the Ministry of Communications of Latvia, for the electrification of the railway line between Riga and Kemmern (the seaside), according to a recent article in the Latvian Economist. The railway administration intends to electrify the Libau station and depots with current from the Libau naval port, at an estimated cost of 6,000,000 German marks.

Electrification Planned in Jamaica

A $10,000,000 project for the electrification of the Government Railway is planned by the Jamaican Government, according to the Times Trade Supplement, London. Of this amount it is said the pipe and conduit lines will cost about $2,000,000, on which a 5 per cent saving can be effected by buying from the United States. Seven substations at a cost of $800,000 are suggested, while trolley wire, feeders, transmission and communication lines will total $4,000,000. Twenty-one electric locomotives are estimated at $1,250,000.

Electrical Hazards and Their Safeguards

The next regular meeting of the American Society of Safety Engineers will be held on May 27, at 8 p. m., in the Engineering Societies Building, 29 West 39th street, New York. The general subject of the meeting will be Electrical Hazards and Their Safeguards. The following papers will be presented: High Tension Electric Generation and Transmission, by C. O. Van Dannenberg and W. W. Samuels, electrical engineers, J. G. White Engineering Corporation; Electrical-

Hazards-Terminal Equipment of the New York Central Railroad Entering New York City, by H. S. Balliet, assistant terminal manager, Grand Central Station, New York; Small Motor Problems and Industrial Control, by L. E. Smith, electrical engineer, General Electric Company. The papers will be illustrated with lantern slides.

New Method of Assigning Sleeping Car Reservations

The Santa Fe Magazine tells of an innovation that means much in the way of convenience to sleeping-car passengers, as well as in insuring the avoidance of confusion and eliminating in large part the possibility of error in the assignment of berths, which was made recently on the Atchison Topeka & Santa Fe Ry. It has now been thoroughly tried out and the results obtained have been so satisfactory that its continuance is assured. It is based on a new method of numbering Pullman cars. Heretofore the number of the car gave no indication of the train number, nor were the cars in a train arranged in numerical order as a general rule. Under the present arrangement, which was worked out by the passenger department of the road, any one can tell at a glance by the car number on a Pullman ticket just what train the holder of the ticket is intended to travel on and in just what location in that train his car will be. For example, on No. 3, the California Limited, the rear car is numbered 30, the one next to it 31, and so on consecutively toward the locomotive. In the second section the numbers start with 300. If a third section is run the numbers start with 310. The first figure in any car number thus indicates the number of the train in which it is located, and the subsequent numbers indicate whether first, second or third section. Therefore, when a passenger has occasion, at the depot or elsewhere, to make inquiry of a railroad employee as to the location of his reservation, he can immediately be advised on what train he has a reservation and just where his car will be located.

New York to Fight Federal Water-Power Control

The New York State Legislature recently passed the resolution which follows and as a result, it is expected that the question of states rights as distinguished from those of the Federal government under the water-power law will be fully reviewed before the courts:

Whereas the Federal government has by the act of Aug. 8, 1917, assumed jurisdiction over the water-powers of this state in common with other states and is now assuming to act in relation to the disposition of the same for national purposes to the exclusion of the state; and

Whereas such water-power belongs to the State of New York and to its citizens, subject only to the right of the Federal government to control navigation, and the Federal government is not vested by the Constitution with any right or power of control over water power; and

Whereas such water power and the right of control over the same are of great value to the people of the state for public use for heat and power as a course of commercial development and revenue to the state, of which they will be deprived under said law by the action of the Federal government;

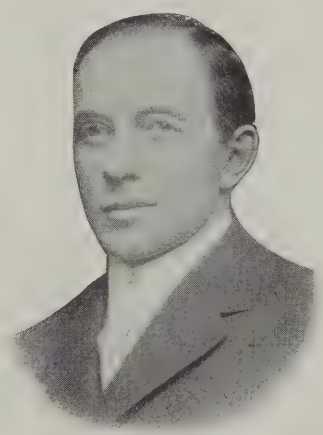
Now, therefore, be it resolved, That the Attorney-General of this state be and he hereby is authorized to take such action as he may be advised in the premises for the effectual protection of the interests of this state and that he is further authorized to co-operate with the duly constituted authorities of other states to the same end.

French Commission Studies American Water Power

A commission of French engineers recently toured the United States for the purpose of studying American water power projects with the idea of securing as much information as possible to assist in exploiting the water power resources of France. P. G. Feuilly, head of the commission, said "Nine million horse power is going to waste in French streams. This is equal to 40,000,000 tons of coal, and at last we are going to employ it. At present France derives about 1,500,000 horse power from her streams. It is to be the policy of the government to develop every possible pound of water power energy. Besides harnessing the streams that have their source in the French and Swiss Alps, we shall extract power from the streams rising in the central plateau and in the Pyrenees. The two principal streams to be utilized are the Rhone and the Dordogne."

Personals

F. B. Jewett, chief engineer of the Western Electric Company, has been elected vice-president and director of the company, continuing his present duties in charge of the technical forces of the company, Dr. Jewett, who was a lieutenant-colonel in the Signal Corps during the war and was decorated with the Distinguished Service Medal, was born at Pasadena, Cal., on September 5, 1879. He was graduated from the electrical engineering course of Throop Polytechnic Institute, of Pasadena, in 1898. From that time until June, 1902, he was a graduate student at the University of Chicago. During the next two years he was instructor in physics and electrical engineering at the Massachusetts Institute of Technology. Dr. Jewett's connection with the commercial telephone business dates from September, 1904, when he became transmission engineer for the American Telephone & Telegraph Company. While acting in this capacity, the loading of eight gage circuits was perfected; phantom cables and phantom loading for open wires and cables were developed; the New York to Denver circuit and line was engineered and



F. B. Jewett

also the Boston to Washington underground cable. In April, 1912, Dr. Jewett became assistant chief engineer of the Western Electric Company in charge of all development and research work. He has been chief engineer since 1916. Dr. Jewett was an advisory member of the Special Submarine Board of the Navy and contributed much towards the perfection of devices for detecting hostile submarines. The perfection of wireless telephoning is one of the undertakings which was completed under his direction.

W. J. Davis, Pacific Coast engineer of the General Electric Company, has been transferred to the International General Electric Company and will soon leave for London and later for South Africa, where he will remain about one year studying the proposed electrification of the present steam railroad between Capetown and Pietermaritzburg, a distance of approximately 800 miles. Mr. Davis states that electrification will defer double-tracking fifteen years. Mr. Davis was born in Louisville, Ky., in 1869 and after being graduated from the Rose Polytechnic Institute in 1892 spent three years in construction work, at which time he entered the employ of the General Electric Company at Schenectady in the students' course. In 1898 he was transferred from the special testing department, where he was then foreman, to the railway and traction engineering department He was engineer on some of the most notable early electrifications. Mr. Davis has been in his present position for eleven years.

Obituary

Willard L. Candee, formerly for about 20 years previous to 1915, president of the Okonite Company, Passaic, N. J., died on April 24 of heart failure in New York City, while on an automobile trip from Long Island. He was born 70 years ago at Yonkers, N. Y., and was one of the pioneer men in the telephone field, also in the electrical lighting field. He was associated with Charles A. Cheever in organizing the first telephone company in New York City, in the early eighties. In 1884, with Mr. Cheever, he organized the Okonite Company for manufacturing insulated wires and cables for electrical purposes, and about ten years later he became president of that company. Mr. Candee remained as president until he retired from active business five or six years ago.

W. L. Candee

Trade Publications

Westinghouse Electric & Manufacturing Company has issued a pamphlet on the electrification of the N. Y., N. H. & H. R. R., with especial reference to the road's six latest electric locomotives which are described.

Archbold-Brady Company, Syracuse, N. Y., has published a booklet illustrating and describing the transmission lines of the Niagara Falls Power Company constructed by it, which involved some special engineering problems.

Iron-Clad Solenoids is the title of a new 4-page leaflet being distributed by the Cutler-Hammer Manufacturing Company, Milwaukee, Wis., which describes electric solenoids for operating brakes, clutches, valves and similar devices where a straight line motion is desired.

The Goulds Manufacturing Company, Seneca Falls, N. Y., has issued a catalog describing the Goulds "Autowater" system, electrically-driven pumps, etc. The company is also circulating a small booklet giving instructions for the installation, operation and care of Goulds "Hi-Speed" pumps.

Accessories for Moving Bridges.—Bulletin No. 1 issued by Norwood-Noonan Company, Chicago, Ill., illustrates and describes briefly auxiliary apparatus used in conjunction with bridge operation, such as gasolene engine units, gasolene engine dynamo units, limit switches, bridge lamps and control switches.

McGill Manufacturing Company, Valparaiso, Ind., has recently issued a small envelope folder, illustrating and describing various types of wire lamp guards used for the protection of incandescent bulbs from breakage and theft. A safety vapor proof portable guard is also shown. A price list of the various guards is given in the folder.

Welding Specialties.—A small pamphlet has recently been issued by the Transportation Engineering Corporation, 200 Fifth avenue, N. Y., which describes and illustrates a number of the electric arc welding accessories manufactured by this company. The specialties described are welding helmets, goggles, a portable sand blast, a metal electrode holder and various types of coated electrodes.

Sprague Electric Works of the General Electric Company, New York, has recently issued a 24-page pamphlet known as Bulletin No. 48,967, which is devoted to an extensive description of the various types of electric hoists manufactured by the company. A large number of photographs are shown from which may be seen the application of such hoists in industrial plants of all kinds. One section of the bulletin is devoted to the illustration and description of vertical winches; a number of photographs showing these winches pulling coal cars, barges and heavily loaded wagons up steep inclines.

Sangamo Electric Company, Springfield, Ill., in its Bulletin No. 56, just issued, explains the use of amperehour meters for controlling electroplating operations. The special type of amperehour meter described is calibrated to read in weight of metal deposited, and the meter is so arranged that it may be set to stop plating operation when any desired weight of metal has been deposited. Gold plating requires the use of two meters connected in series. Both meters measure the amperehours supplied to an auxiliary load furnished by a rheostat, but one of them measures in addition the amperehours used in the plating operation. The difference between the readings in these two meters gives an accurate measure of the amount of gold deposited.

Railway Electrical Engineer

Volume 12 JUNE, 1921 No. 6

The Wage Reductions

A wage reduction of approximately 12 per cent affecting all employees of Class 1 railroads will go into effect on July 1. This reduction will be accepted in some cases without, and in other cases with, protest, but it is not probable that many men will leave railroad service because of it. If the railroads are to continue to function at all as self-contained institutions, operating costs must be reduced. The average monthly wage of the railroad employee will be reduced from $141 per month to $125 per month, and the saving to the railroads will be $400,000,000 yearly. The largest reduction is in the wages of section men who are for the most part unskilled workers. They will be reduced 18 per cent or, from a daily basis of $3.70 to $3.02. This puts section labor back where it was before the wage award on July 20, 1920, but leaves its wages averaging about 38 cents an hour, which is more than is now being paid for labor in most other industries. Journeymen electrical workers will be reduced 9.5 per cent, or from $6.75 to $6.11 per day, which still leaves them 6 per cent ahead of where they were before the wage award of July 20, 1920. Electrical workers with less than four years' experience will be reduced 11.5 per cent, or from $5.57 to $4.93 per day. It is always hard to accept any reduction in wages because there is nothing easier than getting used to prosperity, but the reductions are not as great as the reductions in the cost of living. General business conditions will improve quickly if the railroads are restored to a prosperous basis.

Semi-Annual Meeting Omitted

In view of the business depression which is almost world-wide in practically every phase of business, it is not surprising that the regular semi-annual convention of the Association of Railway Electrical Engineers at Atlantic City will be omitted this month. The Summer meeting invariably consists of a presentation of progress reports of the various committees of the association. The chief loss from the omission of this year's gathering is not so much the lack of the progress reports as it is the loss of opportunity of the association members to meet each other and learn what the other fellow is doing. Even this disadvantage is overshadowed by the fact that the supplymen decided not to exhibit this year, for it is generally recognized that a factor of great value is the extensive exhibition of electrical and mechanical devices which is displayed coincident with the meeting of electrical men.

Although the decision of the Railroad Supply Manufacturers' Association not to exhibit this year at Atlantic City was undoubtedly the underlying reason for the abandonment of this month's convention, it would be most unreasonable to expect such an exhibit this year. The expense involved in transporting and locating the various exhibits is large and many of the companies who regularly made a practice of exhibiting have been obliged to curtail expenses in every possible way.

There are indications that business conditions are on the mend and while the period of convalescence may be somewhat lengthy, it is the opinion of many that commercial matters in general are in a healthier condition to-day than they were a year ago in spite of the greater amount of money in circulation at that time.

The Association of Railway Electrical Engineers has already announced its determination to hold its regular annual convention in October at Chicago. It would have been a mistake to have done otherwise, for the important matters to be discussed by the association are calling loudly for attention.

By that time let us hope that the clouds of financial depression will have entirely disappeared and that the sunshine of prosperity will again look down upon a busy commercial and industrial world.

Why Not Buy Power?

The committee on electrification of steam railroads at the recent National Electric Light Association convention in Chicago touched on a very important subject, when it urged all central stations of electric companies to commence at once a program looking toward a standardization of methods and voltages such as will permit railroad electrification at the earliest moment. This does not mean one voltage or one frequency or one type of locomotive, but means reducing the number of each to the most practical minimum. There is little argument except expense that is ever introduced against steam road electrification. The advantages of electrification are generally recognized both by railroad officers who have dealt with it and by the traveling public. The expense of electrifying a system is so great, however, that any general adoption of electric motive power is still a long way off. There are, nevertheless, roads that have reached the utmost limit of traffic movement by steam power and which, in order to increase capacity, can better afford to electrify than to build more tracks.

Other roads which have not yet reached such a critical condition, but which are gradually and certainly approaching it, are giving more than fleeting consideration

to the subject of ultimate electrification. Through it all looms the great factor of initial cost, and anything that can minimize this cost will be a powerful factor in winning more and more advocates to the electrification projects.

Among the other items usually included in the first cost of electrifying any steam line is the construction of power stations. While the expense of erecting such buildings and installing the generating units is not such a formidable factor as supplying electric locomotives and making other changes necessitated by the adoption of electric power, the cost of such buildings and equipment is a very real expense. If roads could purchase power for their operation from large dependable commercial stations, it would materially reduce the initial investment required and in some instances this reduction might be sufficient to decide in favor of electrification.

With regard to power supply, the most important factor is dependability. If this can be assured from a commercial company it would seem that there is little or no advantage to be gained by making the railroad bear the initial cost of power stations. The generation of power in large central stations has been reduced to such an exact science that it is highly improbable that any railroad could generate its own power cheaper, if indeed, it were able to do it as cheaply. Moreover, when the responsibilities of power supply are removed from the electrical forces of the road, it at once becomes possible to devote more attention to the rolling stock and line maintenance, thus placing the road in a position to furnish better transportation.

Efficiency and Life of Lamps

There is an opinion which is more or less prevalent among the users of lamps on the railroads that the efficiency and candle-power of a type C gas filled lamp falls off rapidly at some period in its life. This may be founded on fact in isolated cases, but is not characteristic of the gas filled lamps. The candle-power falls off gradually during the life of the average gas filled lamp much in the same way that it does in the case of the type B vacuum lamp, and manufacturers make an effort to produce lamps which will all give something more than 80 per cent of their original candle power at the time they burn out. The life of the two types is about the same.

The mean or average efficiency of the 100-watt, 110-volt type C lamp throughout its life is almost 97 per cent, while that of the 100-watt, 110-volt type B lamp is only about 89 per cent. This is according to the last report of the lamp committee of the National Electric Light Association based on the findings of a testing laboratory not controlled by a manufacturer. The following is the part of the report which deals with the 100-watt lamps:

Although Mazda C lamps have largely supplanted the higher wattage vacuum type, and the 100-watt vacuum lamp is no longer regularly listed by the manufacturers and the demand for this lamp is decreasing, this lamp (100-watt vacuum) is still being used to a considerable extent. The continued demand for these high wattage Mazda B lamps indicates that the relative efficiency and cost of lighting from the Mazda B and C types have not been given due consideration. The committee feels that the attention of member companies should be called to the desirability of the substitution of the gas filled type of lamp in both the 75 and 100-watt sizes.

The initial efficiency in lumens per watt of the Mazda B lamps is 10.22 as against 12.57 for the Mazda C, indicating that the latter type is 25 per cent more efficient than the Mazda B lamp. In addition, the Mazda C lamp has better candlepower maintenance during life. For example, the mean lumens per watt throughout the life of the 100-watt B lamp is 89 per cent of the initial, and about 97 per cent with the type C. This means that the efficiency of the 100-watt Mazda C lamp throughout life averages 33 per cent better than that of the Mazda B of the same wattage.

Attention is directed, however, to the fact that the Mazda C lamp is somewhat inferior in ruggedness to the Mazda B, and under some service conditions the advantages and economy in Mazda C lamps may be diminished. The committee understands also that local conditions may, in some cases, have a bearing on this subject, but generally speaking it is felt that the importance of supplying to the public lamps best suited to their service draws attention to the foregoing and the committee suggests that where 100-watt Mazda B lamps are used in considerable quantities the matter be carefully considered by member companies.

In considering this information, it must be remembered that the committee is dealing only with 100-watt units. The small type B lamps are more practical units than is the 100-watt size. The relative differences in efficiency of the two kinds of lamps falls off as the sizes decrease. Comparative ruggedness is also a factor in certain cases in favor of the type B lamp, but the type C lamp is now finding much favor in car lighting service as the 32-volt lamps are much more rugged than those for higher voltages. Manufacturers are now producing 15- and 25-watt gas filled lamps for 32 volts that are sufficiently rugged to meet the requirements of car lighting service.

The 15-watt lamp is only about 10 per cent more efficient than the 15-watt type B lamp and the small type C lamps are practically all coated or frosted, as few of the small reflectors in which they are used are designed to protect the eyes of the passenger from the direct light from the filament with its high intrinsic brilliancy. When this coating is sufficient to diffuse the light from the filament properly, it absorbs about 10 per cent of the light. It is, therefore, a question as to which type of lamp to use in such small units. The efficiency is about the same and the whiter light and somewhat better light distribution, due to the more concentrated filament must offset the higher cost of the gas filled lamp. The gas filled lamp should not be used where vibration is excessive, or for general lighting purposes where the light is close to the workman unless he is protected from the direct rays by a proper reflector or coated bulb or globe. In general, however, it can be said that the gas filled lamp should supplant the vacuum lamp except in the smaller sizes where its advantages are not sufficient to offset the greater first cost.

New Books

The Mathematical Theory of Electricity and Magnetism. By J. H. Jeans. Fourth edition. Published by University Press, Cambridge. 1920. 627 pages, 7x10 in. Bound in cloth.

Contents:—Electrostatics and current electricity.—Magnetism.—Electromagnetism.—Relativity.

There is a certain well-defined range in electromagnetic theory, the author states, which every student of physics may be expected to have covered with more or less thoroughness before proceeding to the study of special branches or developments of the subject. The present book is intended to give the mathematical theory of this range of electromagnetism, together with the mathematical analysis required in its treatment. It is written for the student and for the physicist of limited mathematical attainments.

The main changes in the fourth edition consist in a rearrangement of the later chapters and the addition of a new chapter on the theory of relativity. This attempts to present the broad outlines of the theory in the simplest possible way, suitable for students who approach the subject for the first time.

Electric Passenger Train at Airolao

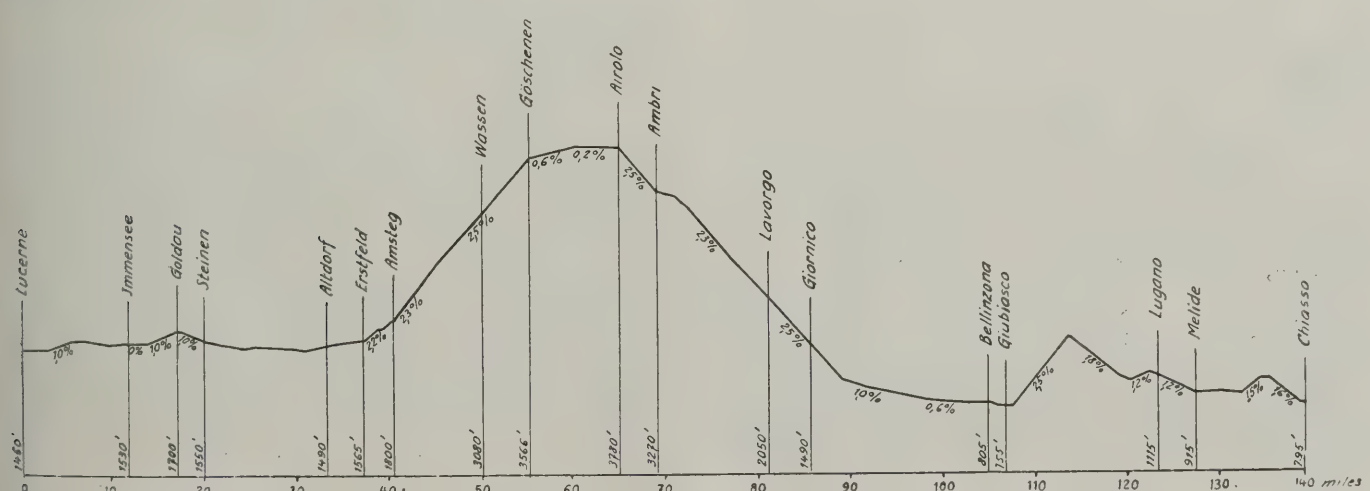
Electrification of St. Gotthard Line, Switzerland

Road Has 60 Trains a Day, Average Grade of 2.5 Per Cent for 30 Miles and Coal Is at a Premium

By Hans W. Schuler
Electrical Engineer, Swiss Federal Railroads

THE Swiss Federal Railroads decided to electrify the St. Gotthard Line from Erstfeld to Bellinzona, a distance of 101 miles, in August, 1913. The Gotthard Line extends from Lucerne to Chiasso on the Italian border, a distance of 180 miles. The part of the line which is electrified with its heavy grades, long tunnels and with the great differences in altitudes that are to be overcome, represents a mountain railroad of the first order.

In 1912, the amount of traffic handled from Erstfeld to Bellinzona was about 405,000,000 ton-miles. Every day 20 through trains, 8 local trains, 22 freight trains and from 10 to 20 special trains were run over this line. The best material and methods of construction obtainable were used, because of the heavy traffic, the severe climatic conditions and the importance of the line as a main connection between Germany and Italy. Nothing was omitted in an effort to obtain a quality of material and standard method of construction that might secure an uninterrupted, reliable service.

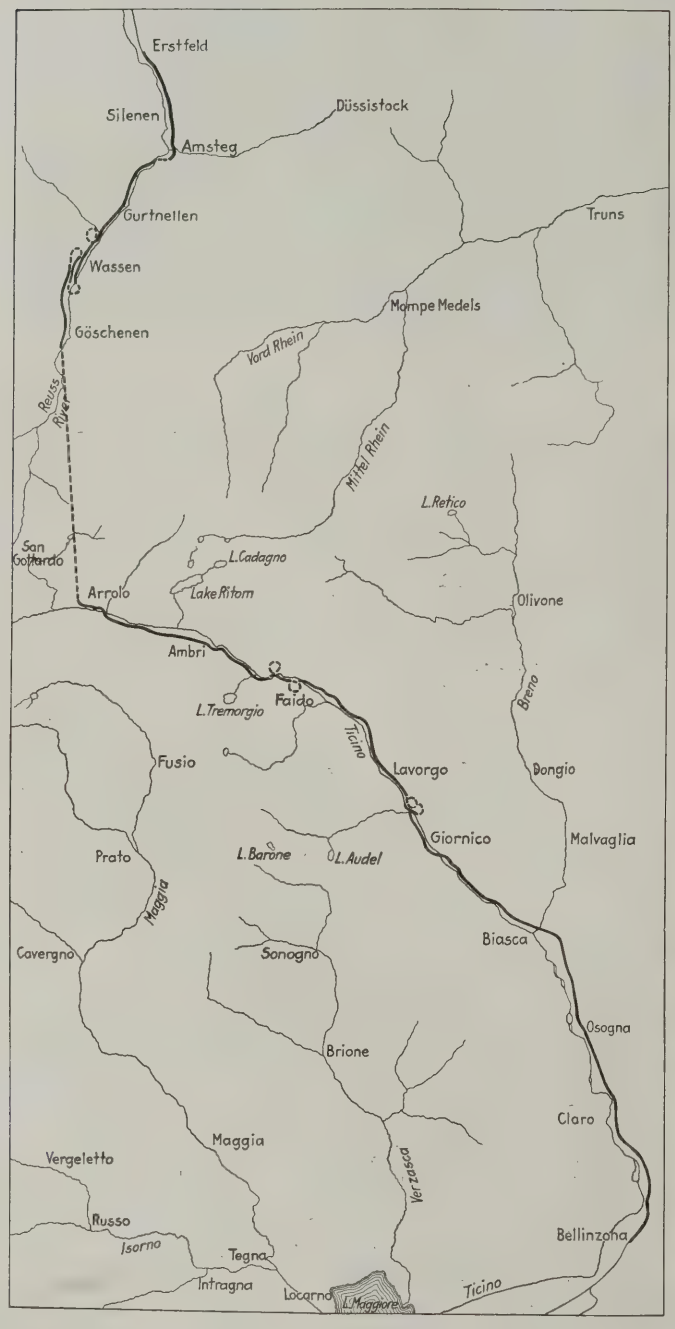


Profile of the St. Gotthard Railroad. This Section from Erstfeld to Bellinzona Has Been Electrified

The electrified section is all double track and has the heaviest and longest grades of any of the standard gage railroads of Switzerland. The northern part, from Erstfeld to Goeschenen, at the northern portal of the St. Gotthard tunnel, has an average grade of 2.6 per cent

on a length of 18.7 miles, and the southern part from Biasca to Airolo, at the south portal of the St. Gotthard tunnel, has an average grade of 2.5 per cent for a distance of 28 miles.

The original plan for electric power called for two power stations equipped with single phase generators, one situated near Amsteg in the Reuss Valley, on the north side of the Alps, and the other near Ambri-Piotta,



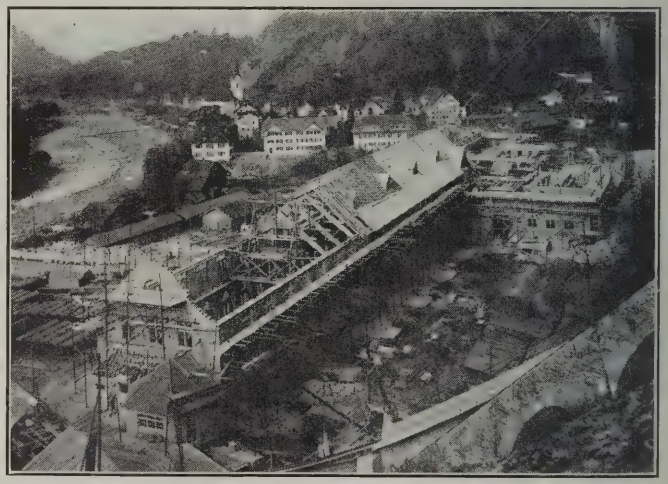
Map of the Electrified Section of the St. Gotthard Railroad

on the south side. In 1914 the work of building these power stations was started and it was planned to get them finished and ready for service in 1918. The world war checked this program. Because of the enormous difficulties created by the war, it was necessary to neglect some of the construction work of the Amsteg power station and concentrate the work of building on the Ritom power station at Ambri-Piotta. This station began to deliver current to the contact line in the spring of 1920. The reason for this procedure was as follows: When Italy entered the war the traffic on the St. Gotthard Line diminished considerably. It was evident then, that this traffic regress would continue for some time. The Ritom power station should be able to furnish all of the power required to run trains until about 1922, and it seemed admissible not to hasten the construction work of the

The Ritom Power Station. Pressure Pipe Lines from Lake Ritom Are Brought Down Through Cleared Space in the Timber Shown in the Rear

Amsteg power station, but to wait a year or two for a time with better conditions for construction work.

Because of the difficulties involved in getting materials from other countries, such as iron, copper and insulators, the construction of the contact line was delayed. Other obstacles encountered were the necessary reinforcement of the numerous bridges, due to the fact that the electric locomotives were heavier than the steam locomotives dis-



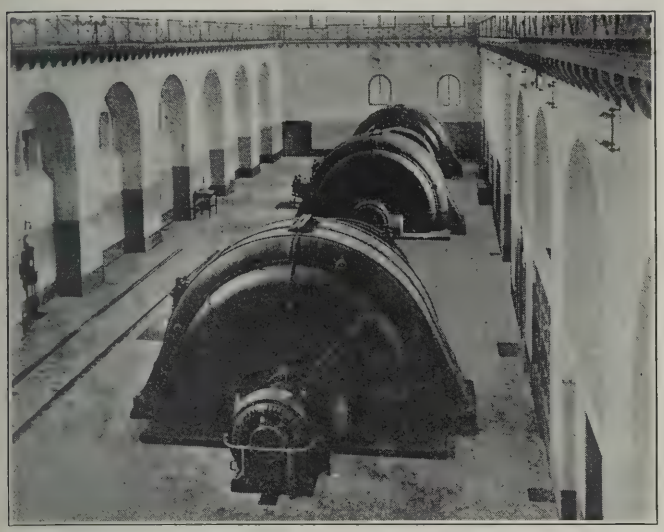
The Amsteg Power Station Under Construction. Photograph Was Taken in November, 1920

placed, and to the necessity for rebuilding the stations at Goeschenen, Airolo and Bellinzona, which had reached their capacity in 1913. In spite of these delays, the contact line through the St. Gotthard tunnel was ready for service in May, 1920, when the Ritom power station began to supply current. In July, the construction of the contact line from Erstfeld to Goeschenen was completed and in November the contact line from Airolo to Biasca was ready for service. The great amount of rebuilding

work now going on in the station of Bellinzona will make it impossible to start electric operation from Biasca to Bellinzona before early summer, this year.

The Power Stations

The power station at Ritom is a hydro-electric plant with a head of 2,620 ft. Lake Ritom, situated about 2,950



Interior of Ritom Power Station at Ambri-Piotta

ft. above the village of Ambri-Piotta, at an altitude of 6,000 ft., is used as a reservoir, and the water is held in the lake by a small dam at the outlet of the lake. The useful volume of the lake is 918,000,000 cu. ft. and the average outflow is 35.3 cu. ft. per second. This flow and head maintain a continuous output of 8,500 hp. at

Catenary Construction on Tangent Track

the shaft of the turbine. The reservoir capacity of this plant makes it admirably suited for co-operation with the plant at Amsteg, which has a varying output caused by the widely fluctuating flow of the Reuss River on which it is located. The Ritom power station is now built for an output of 48,000 hp. and its capacity will later be enlarged to 72,000 hp. At present there are three 9,000 kva. generators in service, each direct connected to a 12,000 hp. Pelton turbine, while a fourth set is being mounted. The generators develop single-phase, 15,000-volt power at a frequency of 16 2/3 cycles. The current is delivered directly to the contact line at the power stations and also to 11,000 kva. transformers which step the voltage up to 60,000 volts to transmission lines which take it to the various sub-stations. At present it is necessary to mix electric traction with steam traction between Biasca and Bellinzona, and until it is possible to discontinue this practice, the tension on the contact line will be maintained at 7,500 volts.

The Amsteg power station uses the fall of the Reuss River. A pressure tunnel, 4½ miles long, conveys the water to a water chamber 920 ft. above the powerhouse.

Catenary Construction on Curve. Supporting Bridge in Foreground. Second Bridge Is a Pull-Off

The average minimum output during the three winter months is 12,000 hp. at the shaft of the turbines. Water wheels aggregating a total of 60,000 hp. will be installed at first and later increased to 90,000 hp. The Amsteg power station should be ready for service early in 1922, and as soon as it is put in operation the Ritom station will be practically idle in the summer, thus allowing a

Catenary on a Curve Showing Another Type of Pull-Off Construction (See Preceding Illustration)

large volume of water to accumulate in Lake Ritom, while Amsteg, due to the immense flow of water in the Reuss River during the summer months, will be able to generate all the power that is needed to run all trains over the St. Gotthard Line. During the three winter months the Amsteg station will have its output limited

to 12,000 hp. and Ritom will be able to satisfy the balance of the power demand by drawing on the water accumulated in the lake during the summer months.

Transmission Lines

From the power stations, the power is transmitted over 60,000-volt transmission lines to the sub-stations. Between the Ritom power station and the sub-stations of Goeschenen and Giornico these transmission lines are built as underground cables. As the middle point of the transformer high tension winding is grounded, the tension between each conductor and ground is only 30,000 volts. The cables are insulated to stand 30,000 volts in normal service. Before they are laid they are tested with 90,000 volts. At present there is only one, two-conductor transmission line consisting of two cables of 135 sq. mm. copper cross section each between Ritom and Goeschenen and two lines consisting of four cables of 120 sq. mm. cross section each between Ritom and Giornico. A second line between Ritom and Goeschenen and two lines between Amsteg and Goeschenen are being installed. Each of the cables used in these lines has a cross section of 135 sq. mm.

The 30,000-volt cables are placed on the right of way in concrete channels. Junction boxes are placed in the concrete channels at intervals of about 1,600 ft. for the purpose of making splices in the cable. In the St. Gotthard tunnel the cables are laid in reinforced concrete channels that are attached to the side wall of the tunnel at

Special Contact-Wire Support and Protective Devices Are Used on Highway Bridges

a height of 4 ft. 11 in. above the top of the rail. The channel supports are placed at intervals of 10 ft. 9 in. The insulation of the cables consists of specially impregnated Manila paper, which is covered by a lead sheath 3 mm. thick, which in turn is enclosed in a jute wrapper.

From the Giornico sub-station to the south and from Amsteg to the north, the transmission lines are aerial. The line to the sub-station of Giubiasco is now ready for service and the line further south to the sub-station of Melide will be completed by the end of this year. For the greater part of the distance these lines parallel the track at a distance of 66 ft. and consist of 4 copper strands of 100 sq. mm. cross section. The average distance between poles is 262 ft. A ground wire consisting of a ½ in. galvanized steel strand is strung over the top of the poles. The transmission lines from Amsteg to the north will be built during the coming summer and fall and should be ready for service early in 1922. It will connect the Amsteg power station with the sub-station at Steinen.

Sub-Stations

There are five sub-stations in all. The sub-stations of Goeschenen and Giornico are already in operation, the sub-station of Giubiasco is about completed and the sub-stations at Melide and Steinen will be put in service at the end of this year. In the sub-stations the single phase current from the power stations is transformed from 60,-

Sectionalizing Insulators and Circuit Breakers on Pole in Yard Catenary Construction

000 to 15,000 volts and delivered to the contact line. The sub-stations of Goeschenen, Giornico and Giubiasco are built for the installation of three transformers of 5,000 kva., continuous rating, but only two will be installed until the traffic demands a third. The sub-station at Steinen will be equipped with three and later on with four transformers of 5,000 kva. capacity.

The Contact Line

The contact line is built as a catenary. Over the main line track it consists of a No. 0000 hard drawn copper contact wire, a ½-inch, 19-strand galvanized iron auxiliary messenger and a ½-inch, 7-strand galvanized iron messenger wire. The contact wire is suspended from the auxiliary messenger at intervals of 23 ft. and the auxiliary messenger is supported from the messenger by hangers placed at intervals of 92 ft. The bridges which support the messenger are spaced 184 ft. apart. At these bridges the contact wire and auxiliary messenger strand are held in their position, relative to track, by a special pull-off construction. On curves with radii less than 2,950 ft. the contact wire, the auxiliary messenger and the messenger are pulled off in the middle of the span. The span of 184 ft. was chosen because it was found the most advantageous one with respect to the many curves and because of the small width of the pantograph shoe made necessary by the form of the tunnel. On adjoining lines, where curves are less frequent, the length of span will be 197 ft.

The maximum tension of the contact wire at the low-

est temperature reached in winter is 883 lb. At the highest temperature in summer, this tension goes down as far as 530 lb. With the greater number of catenary systems used in Europe, a constant trolley wire tension is obtained by tension weights used to suspend the contact wire at various points of the line. No tension weights

Sectionalizing Switches Used to Disconnect the Catenary Over the Station Tracks from the Main Line Catenary

are employed in the construction of the catenary on the St. Gotthard Railroad and much care has been taken to obtain a perfectly level contact wire, as the pressure of the pantograph shoe is kept at only 5½ lb.

In the tunnels the auxiliary messenger is replaced by a copper wire that is mounted close to the main contact wire. The messenger is replaced by a copper clad steel wire that has a copper cross section of 28 sq. mm. and a steel cross section of 28.5 sq. mm. The messenger is supported by special frames, which are about 82 ft. apart.

The height of the contact wire above the top of the rail at the highest temperature is 18 ft. on the open line, 19 ft. at highway crossings and 20 ft. in stations. The total difference in height, on account of temperature change, is 1.5 ft. In tunnels and under low bridges the height above the top of rail is 16 ft. at all temperatures.

The contact line is insulated with a double insulation that consists of two pin-type and one spool-type insulators, at all points where the messenger strand is supported and which consists of one pin and one spool-type insulator at the pull-off. On account of the limited space in tunnels it was impossible to install double insulation. As a substitute a pin-type insulator of especially heavy design is used. All of the insulators used have a cylindrical section which makes it possible to use them with a sturdy type of insulator support or armature. The flash-over voltages of these insulators are given in table No. 1:

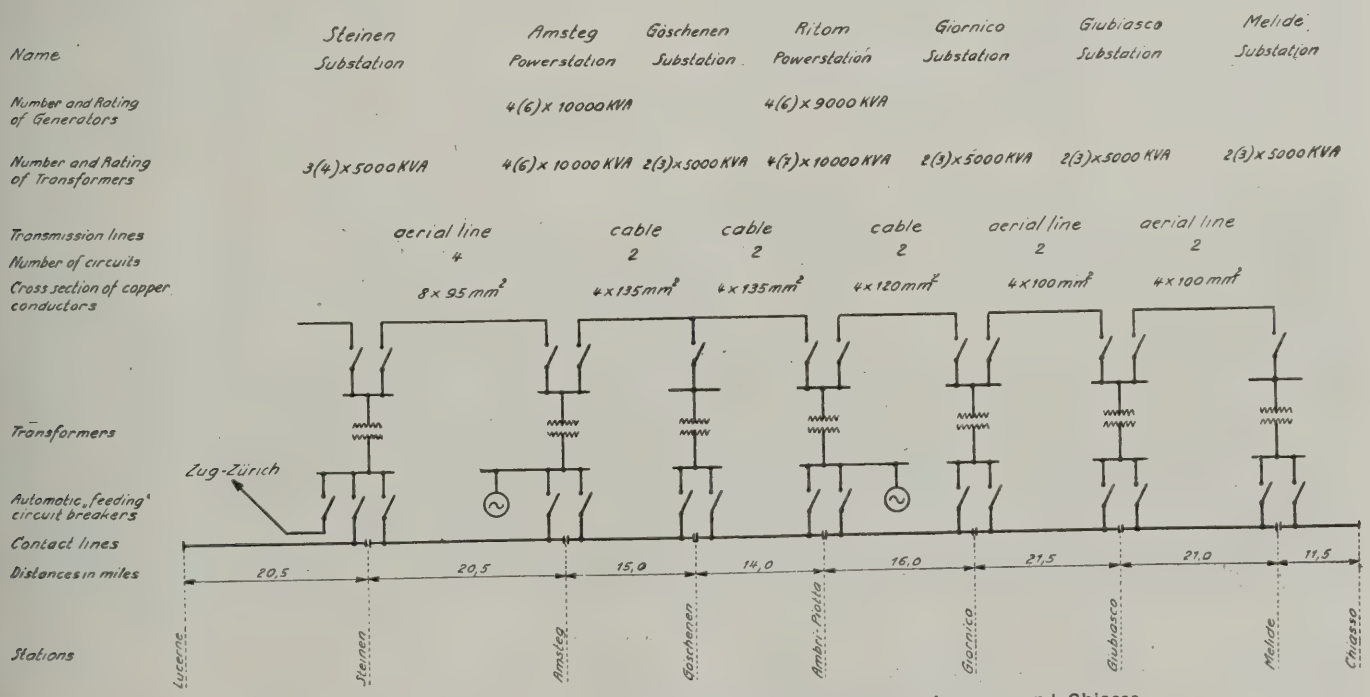
TABLE No. 1

	Tunnel Insulator	Pin Insulator	Spool Insulator
Dry	110,000 volts	83,000 volts	52,000 volts
Under rain of 45 deg. at the rate of 1" in 5 minutes	78,000 volts	58,000 volts	23,000 volts

Previous to their adoption, special tests with the tunnel insulator were made in 1918 on a trial section in the St. Gotthard tunnel. The insulators under test were completely black with smoke and at a moment when two locomotives, giving off thick black smoke, were passing underneath, the insulators flashed-over at a voltage of 29,000 volts.

The yard tracks are equipped with a contact line which consists of the contact wire 70 sq. mm. cross section, of a ⅜ in. 19-strand galvanized iron auxiliary messenger and a ⅜ in., 7-strand galvanized iron messenger.

The pole lines on the open line between Erstfeld and Bellinzona are made of "H" beams 8 in. wide. Between Bellinzona and Chiasso and between Erstfeld and Lucerne structural steel poles are used which have the same mechanical strength. The yokes between the poles are made of two "T's" or of four angles. In the stations, structural steel poles are used with rigid steel cross spans.



General Wiring Diagram of the 15,000 and 60,000-Volt Lines Between Lucerne and Chiasso

All insulator supports and all bolts and small parts for the contact line are heavily galvanized.

Section insulators and switches are so located that all of the track in a station can be disconnected from all others and so that all of the main line tracks between any two stations can also be disconnected from the rest of the system. There are no feeders along double track lines, but feeders are provided on single track lines for continuity of the circuit while repair work is being done on the contact line.

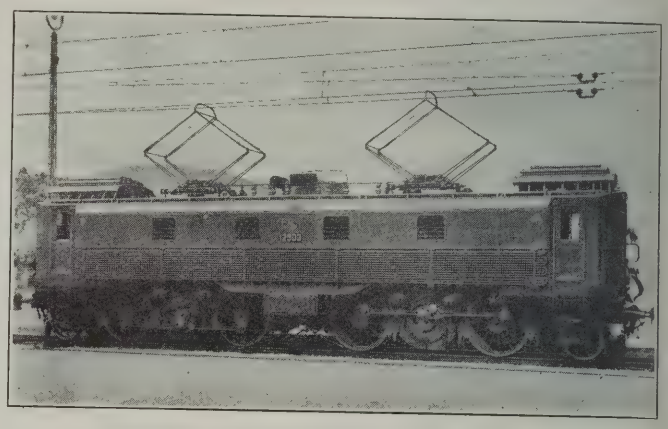
The different sections of the contact line are connected by oil circuit breakers. Four of these circuit breakers are located at either end of every station. When all of the lines are in service, the contact line transmits the current through the stations to points farther away from the feeding point. Each station is provided with a special jumper line that goes around the station and maintains continuity of the circuit when the lines in the station are disconnected.

A special selective system is installed for short circuit protection. The sectionalizing switches are equipped with current transformers and in the case of a short circuit these transformers remove the interlock from the sectionalizing switches and trip the feeder circuit breaker in the nearest sub-station. The operator in this sub-station then tests the line with an auxiliary circuit through a high resistance. If the test ammeter shows more than a definite amount of current flowing through the resistance into the line, he pushes a button that energizes the remote control wires and trips the circuit breaker at each end of the defective section. He then closes the feeding circuit breaker and energizes all of the line but the defective section. The feeder circuit breakers are equipped with an alarm bell and as soon as the section has been made "dead" by the sub-station operator, the line maintainers are notified. All of the remote control wires are contained in a "control cable" that is run underground alongside the track.

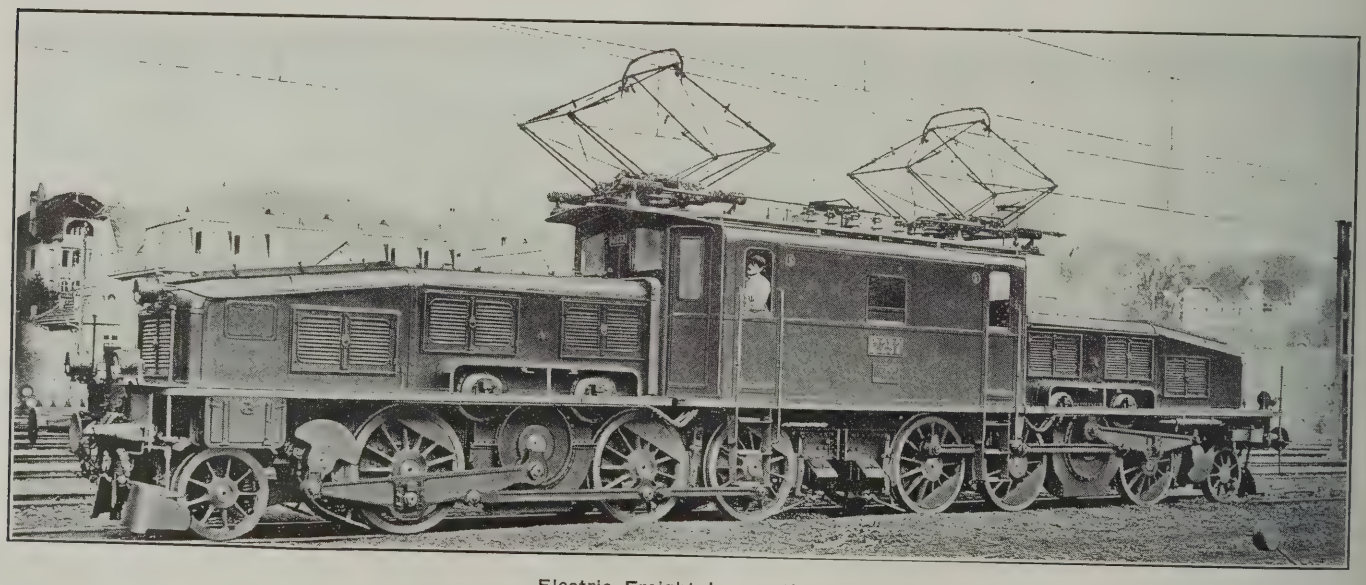
Telegraph and Telephone Lines

All of the telegraph and telephone lines in Switzerland, not owned by the railroads, are owned by the government, and it is common practice to run both government and railroad telegraph and telephone lines along the railroad right of way. As many of these lines use a grounded return, it is not possible to have them on the right of way of an electrified road because of the noise caused by inductive interference and the danger of actual physical contact with the overhead system of the electrified railroad.

On the St. Gotthard line the railroad placed its telegraph and telephone lines in a cable laid in a concrete channel in the right of way and the state removed its lines as far away from the railroad as the rather narrow valley would admit. Along this line, both the railroad and the state have discontinued the use of a grounded return, and as the lines are either in a cable or from 1,640 to 2,600 ft. away from the contact line and frequently transposed, there is no trouble from inductive interference and no danger of actual contact. In some localities the induced voltage in the railroad telegraph and telephone lines runs as high as 240 volts at peak loads, but as the lines are not grounded this does not interfere with normal service.



Electric Passenger Locomotive



Electric Freight Locomotive

Locomotives

When a decision was reached to electrify the St. Gotthard Line, it was planned to obtain trial locomotives as soon as possible and to test them out on the Loetschberg

Railroad for the purpose of finding out which type was the best suited for the St. Gotthard Line. The war also delayed the delivery of electric locomotives for the test, and for this reason the locomotives for the St. Gotthard Line had to be ordered before the trial locomotives had been delivered and tested.

At the present time there are about 30 locomotives in service, 15 of which are freight and 15 passenger locomotives. The data for the two types is given in table No. 2.

TABLE NO. 2

	Passenger Locomotive	Freight Locomotive
Type	2-4-4-2	2-6-6-2
Continuous rating (hp.)	1650	1825
One hour rating (hp.)	1800	2250
Drawbar pull (continuous)	20,000 lb.	26,000 lb.
Drawbar pull (one hour)	23,000 lb.	37,500 lb.
Speed	47 miles per hr.	40 miles per hr.
Length over all	54 ft.	636 ft.
Diameter of driving wheels	60.2 in.	53.2 in.
Gear ratio	1:3.5	1:4.03
Weight of mechanical parts	59.3 tons	72.0 tons
Weight of electrical parts	47.3 tons	56.0 tons
Total weight	106.6 tons	128.0 tons
Weight on drivers	76.8 tons	103.9 tons
Electric parts made by	Brown, Bovery & Co.	Maschinenfabrik Oerlikon
Mechanical parts made by	Lokomotivfabrik Winterthur	Lokomotivfabrik Winterthur

The coal situation, often referred to as the coal misery, reached its climax in 1918 and taught Switzerland to consider steam railroad electrification as a vital as well as an economic problem. With the high prices being paid for coal, many roads could probably show considerable saving if electrified, but more than this it was desirable to maintain the continuity of traffic and not be dependent upon the goodwill of foreign countries for coal. These were the primary reasons for deciding on a program for the electrification of all of the lines of the Swiss Federal railroads, and a decision has been reached not to wait for the completion of the electrification work on the line from Erstfeld to Bellinzona but to go on at once with the electrification of adjoining lines. Table No. 3 lists the Swiss Federal railroads which are electrically operated and those on which the work of electrification is in progress.

TABLE NO. 3

LINES ELECTRICALLY OPERATED

Lines	Length of line	Year operation was started	Kind of power used
Brig-Iselle (Simplon tunnel)	13.7 miles (single track)	1905	Three phase 3000 volts, frequency 16⅔
Brig-Sitten	35 miles (partly double track)	1919	As above
Thun-Bern	20 miles (double track)	1919	Single phase 15,000 volts, frequency 16⅔
Erstfeld-Biasca	56 miles (double track)	1920	As above, but frequency 16⅔

LINES BEING ELECTRIFIED

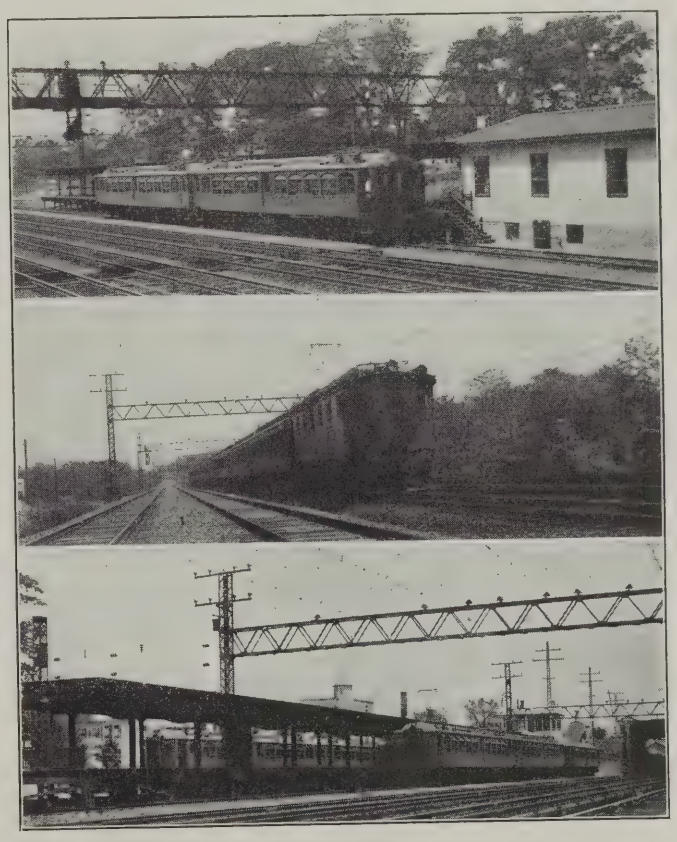
Lines	Length of line	Time work will be finished	Kind of power used
Biasca-Bellinzona	12.5 miles (double track)	Apr., 1921	Single phase 15,000 volts, frequency 16⅔
Bellinzona-Chiasso	34 miles (double track)	End, 1921	As above
Erstfeld-Lucerne	37.3 miles (partly double track)	Apr., 1922	As above
Goldau-Zug	12 miles (single track)	Apr., 1922	As above
Lucerne-Zug-Zuerich	28.3 miles (partly double track)	End, 1922	As above
Sitten-Lausanne	60 miles (double track)	Aug., 1923	As above

Wireless Telephony in Great Britain.—The first installation of wireless telephony for commercial purposes in the United Kingdom was put into operation at Liverpool recently between the head offices of the Mersey Docks and Harbor Board and the Mersey Bar lightship, 12 miles away.

New York, Westchester & Boston Extends Line

THE New York, Westchester & Boston Railway, a suburban electrified line running northward out of New York City, has recently extended its line 1.78 miles from New Rochelle, N. Y., which was originally the end of the line, to Larchmont, N. Y.

The extension consists of two tracks, one for northbound traffic and one for southbound traffic, which parallel four tracks of the New York, New Haven & Hartford road, of which the Westchester is a subsidiary. The overhead bridges which support the catenary construction for the New Haven were originally designed to span six tracks, and since the New Haven uses but four tracks at this point, no additional expense was incurred in constructing the support for the Westchester catenary. The catenary design used on the Westchester consists of a catenary messenger wire which in turn supports the auxiliary messenger wire parallel to and a few inches above the contact wire. This construction differs from that used on the New Haven line, as the latter construction consists of a triangular arrangement of three messenger wires.



Top—Multiple Unit Train at Pine Brook Station. Center—A Southbound Train on the New York, New Haven & Hartford Railroad. The Two Tracks at the Left are Those of the Westchester Line. Bottom—N. Y., W. & B. Station at Chatsworth Ave., Larchmont, N. Y.

Two new stations have been constructed on the new extension, one of these at Pine Brook, in the New Rochelle zone, and the second at the end of the line, which is at Chatsworth avenue, Larchmont. Both of these structures are built of wood and are considered as temporary only, not being up to the standard of the other stations

on the line, which have been constructed of concrete.

As is the case with all of the previously constructed line, the new extension has rock ballasted track and compares with first-class steam railroad construction in every respect.

The most serious drawback which the Westchester road has to contend with is the fact that its stations in New York City are located so far from the business center of the town, the nearest downtown station being at 129th street. The road runs through a most delightful residential section and while it has experienced not a few financial difficulties, there is reason to believe that it will ultimately carry a sufficient number of passengers to justify its construction. At the present time there are 119 trains a day operated between New Rochelle and Larchmont, and during the month of April the approximate number of passengers carried was 51,797.

Scientifically Designed Glass Reflectors

THE subject of electric headlights for locomotives is one which has been receiving a large share of attention from the electrical engineers. Practically all locomotives in the United States today are equipped with electric headlights, some of one manufacturer's make and some of another. Inasmuch as the turbo-generator end of the equipment is the moving part, it is perhaps only natural that a great deal of attention is centred on this particular feature. Nevertheless, the generator is nothing more than a means to an end. It is the source of power for the lighting. Unless this power is properly used and directed, it is evident that a considerable portion of it will be wasted. Therefore, in any consideration of the headlight proper, too much emphasis cannot be placed upon the care that headlight reflectors should receive in the process of their construction.

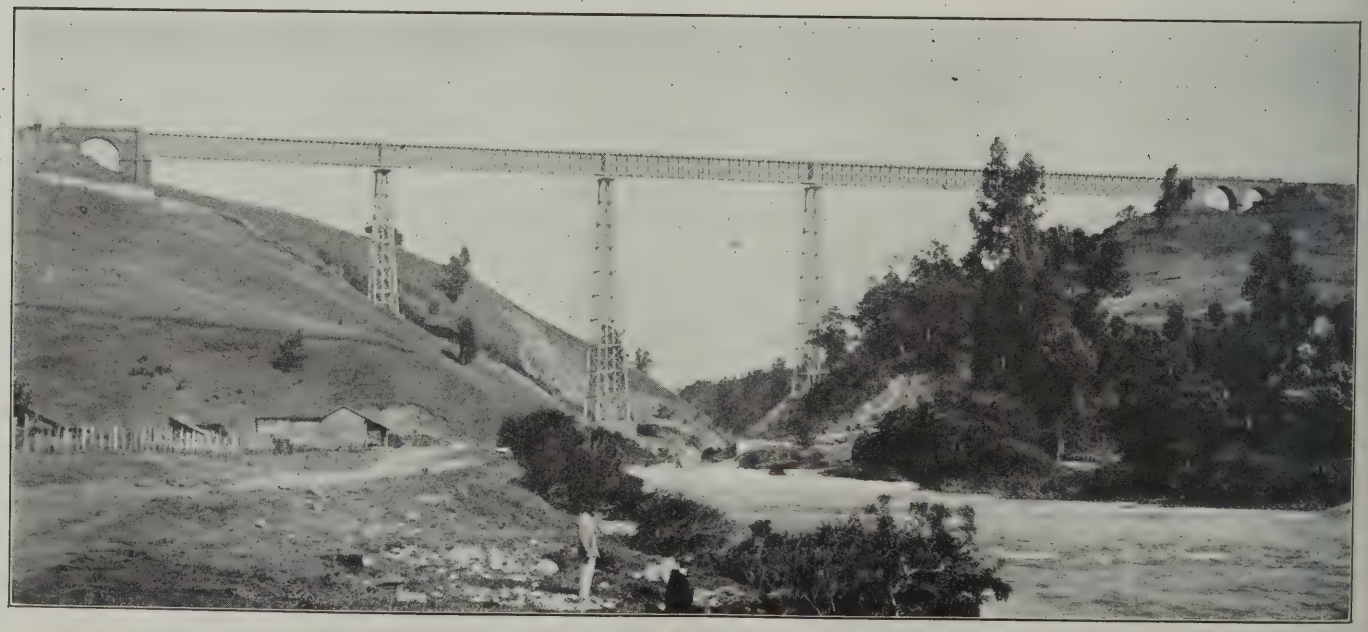
There are two types of headlight reflectors in use today. One of these, the silver-plated copper reflector, requires constant care, which results in high maintenance charges. The other type is the glass reflector which, from its very nature, allows of greater ease in cleaning.

It cannot be denied that in some minds there is a more or less unfounded prejudice against glass reflectors, but it is the greatest kind of a mistake to place all glass reflectors in the same class. Glass reflectors of superior worth, like all other commercial products of especial merit, have been grossly imitated. The results obtained from such imitations have been so inferior and so altogether unsatisfactory that there has been a tendency to attach the stigma of ill repute to all kinds of glass reflectors regardless of their merit.

When such conditions prevail, there is nothing more natural than that reputable manufacturers, who have spent years in the study of perfecting high grade ground glass reflectors, should take some means of pointing out the wide gulf which exists between the mathematically and scientifically designed reflector and the cheap imitation, or substitute, which is inferior in every respect.

In order that those who are interested in this subject may be supplied with specific information concerning the manufacture of glass headlight reflectors for locomotive service, the engineering laboratory of the Electric Service Supplies Company, makers of the "Golden Glow" reflectors, has prepared a comprehensive report which embodies a full description of the scientifically exact refinements which are absolutely necessary in the construction of satisfactory glass reflectors for headlight service. The report is brimful of interesting facts in connection with glass reflectors, and is well worth reading by any electrical engineer having the supervision of headlight equipment.

Railway Electrification in Germany.—A European correspondent of the Electrical World writes that the Ministry of Communications has just made the first appropriation of 40,000,000 marks for the electrification of the railway line from Munich to Regensburg, one of the principal lines in Bavaria.



Malleco Viaduct on the Central Spur, South of Concepcion, Chile

Principles of Car Lighting By Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

XI. — Transmission of the Axle Generator

THE history of car lighting by electricity reveals many experiments in an effort to obtain a drive that is both practical and economical for an axle generator. The gear, chain and flexible shaft drives have been tested but none of these have been able to cope with the existing conditions like the belt drive. It is true that many generators are driven by gears, chains, and flexible shafts in applications other than car lighting, but when a study is made of the method of suspending an axle generator, the lost motion in the running gear of cars, and the track and weather conditions under which a transmission in this service might operate, you will find a problem which is by no means an easy one to solve.

The belt drive is, no doubt, the most practical, but by no means the most economical to maintain. It is this high operating cost that keeps the problem of economical transmission constantly before the car lighting engineer.

Belt Drive

The belt drive consists of a belt equipped with a suitable fastener and two pulleys. One pulley, known as the axle pulley, is fixed to the axle, while the other, a generator pulley, is fixed to the armature shaft.

There are two classes of belting in general use—class 1, for free speed generators, and class 2, for controlled speed generators. The Balata or rubber belting is used with variable or free speed generators, that is, the generators that are regulated by an electrical regulator and

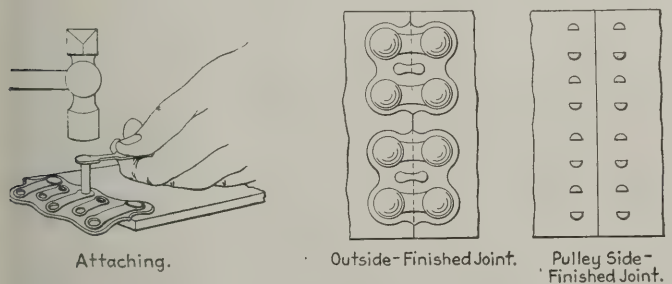


Fig. 1—Crescent Belt Fasteners Riveted Over the Joint of a Generator Belt

when belt slipping is avoided as far as possible. The Balata-Aragoma belting is used with the constant speed generators, that is, generators that are regulated by maintaining a constant speed through the slipping of the belt.

The belting is used in various widths and thickness according to the size of the pulleys and the power they are to transmit. The length of the belts vary also with the length of the drive, but average 10 ft. for truck suspended types and 15 ft. for body suspended types.

A Balata or rubber belt is a good belt for use with free speed generators, but will not stand up so well with the slipping belt type.

The Balata-Aragoma belt will stand the slip and is a good belt for use with the controlled speed types.

Pulleys

Axle pulleys are made of pressed steel and in two halves. They are fixed to the axle over a corrugated steel bushing. The bushing is held in place by four bolts, and likewise four bolts hold the axle pulley to the bushing. The bore of the bushing is straight or tapered, according to the size and shape of the axle at the point of application. The outside diameter of all bushings, however, is made standard so as to fit the bore of the axle pulley.

The generator pulley is much smaller than the axle pulley and bored to fit over the end of the armature shaft. On a truck suspension the axle and generator pulleys ride with their centers in line, both on straight and curved tracks, therefore a generator pulley with straight flanges, and an axle pulley with straight or no flanges is used. The end of the armature shaft is threaded to accommodate a nut for holding the generator pulley in place. Armature pulleys are made of pressed steel, cast steel, malleable iron, cast iron and various composite structures, but cast iron is the most generally used. Pulleys for body hung machines are equipped with special flanges.

The generator pulley is crowned and equipped with flanges—straight flanges for truck suspended generators and tapered flanges for body hung generators.

Belt Fasteners

There are four different types of belt clamps in general use, Crescent, Jackson, Alligator and Walker.

The *Crescent* belt fastener consists of one or more thin steel plates which are held in place by copper rivets. The rivets are made long enough to allow for the thickness of the belt, thickness of plate and for proper clinch. In applying Crescent fasteners the ends of the belt are squared and the plates placed in position and attached with rivets, as shown in Fig. 1. The rivets are applied by the use of a rivet holder and hammer, and are clinched so that the prongs spread across the belt, as shown in Fig. 1. The size of the clamp and rivets varies with the size of the belt as follows:

Belt Size	Fasteners	Rivets, Large Shank
4″-4 ply	No. 65	12½″
4″-5 ply	" 65	12 9/16″
5″-4 ply	" 87	16½″
5″-5 ply	" 87	16 9/16″

This clamp is used with belts on truck suspended generators that have a small truck clearance.

The *Alligator* belt fastener, Fig. 2, is clinched to the ends of the belt by a double row of teeth and is connected by the use of two steel pins, forming a hinged

joint. In applying the Alligator belt fastener, the ends of the belt are cut square and the lacing is held over a gage pin and clinched to the end of the belt with a hammer, as shown in Fig. 2.

The following sizes are used with the various size belts.

Belt Size	Size of Fastener
4″-4 ply	No. 35
4″-5 ply	" 45
5″-4 ply	" 35
5″-5 ply	" 45

The Alligator is a good clamp for belts with truck suspended generators as it requires but little belt clearance. It has an advantage, too, in fact that a belt equipped with this type of clamp can be applied and removed in a short space of time.

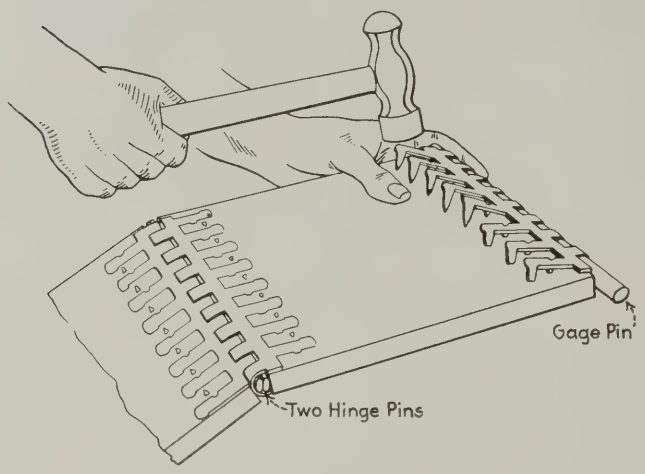


Fig. 2—Applying Alligator Belt Fastener

The *Jackson* belt fastener consists of three metal straps and a canvas liner or safe. In applying the Jackson belt fastener the ends of the belt are squared and butted together and then the safe and strap are bolted in place as shown in Fig. 3. The Jackson belt fastener may be used with belts on both body and truck suspended generators if there is sufficient belt clearance.

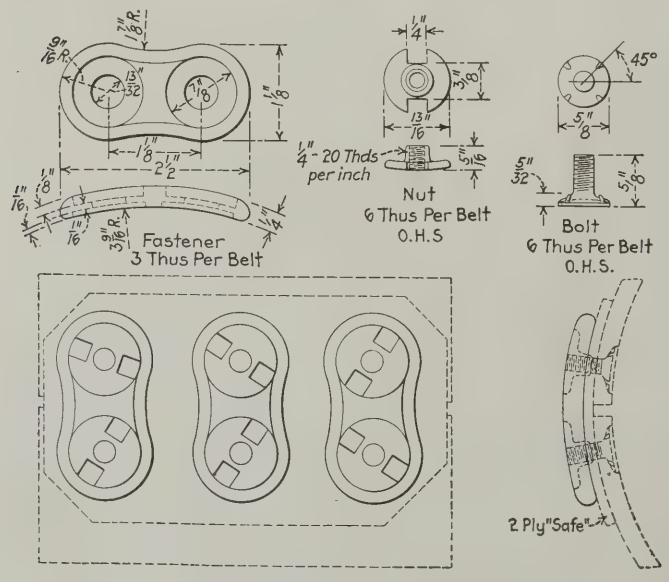


Fig. 3—Details of the Jackson Belt Fastener

Walker belt fasteners consist of two metal plates, two links and two hinge pins. In applying this fastener, the ends of the belt are squared, then a line is drawn square across the belt 1 inch from each end. On these lines holes are punched for the fasteners. Fig. 4 shows the arrangement of this fastener. The size of the Walker fastener varies with the size of the belt as follows:

Belt Size	Fastener
4″-4 ply	No. 21821
4″-5 ply	" 21822
5″-4 ply	" 22655
5″-5 ply	" 22561

The Walker is a good fastener for belts with body hung generators. The pulleys are out of line when the car rounds curves, and causes the belt to ride the pulley flanges. This requires a fastener that will allow the belt to be flexible and bend under the clamp in this action.

Belt Tension

The belt tension on a controlled speed generator is set so that the belt will slip at a predetermined speed. The belt tension on a truck suspension is adjusted so that the belt will not slip because slipping in this case would cause the regulator to pump and flicker the lights.

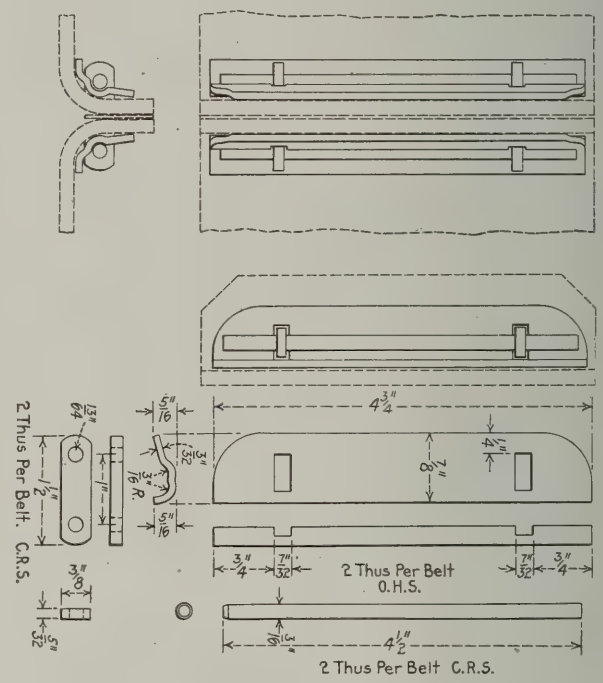


Fig. 4—Details of the Walker Belt Fastener

Generator Suspensions

Generator suspensions, of which there are many types are all provided with some means of applying the proper tension to the belt. These suspensions, although they vary extremely in design, may be divided into two general classes, body type and truck type. That is, every generator suspended from the truck, whether it be a two point, four point or rigid suspension, is a truck suspended generator. Likewise a generator suspended from the car body regardless of the design of the suspension is a body suspended generator.

The following is a description of a truck suspension which is given in an effort to bring out a few points in comparison between truck and body suspension on a belt tension and belt life.

Truck Suspension.—The truck suspension, Figs. 5 and 6, consists of a frame carried on two bars which are sup-

ported by the truck. It will be seen that the generator is provided with four lugs *C*. These lugs are drilled for two supporting shafts *D*, which pass through the lugs and through solid links *A*, the links being as long as the distance between the lugs. The lower end of each link *A* is supported by a shaft which passes through the link and supporting frame *B*. No wear can occur on the

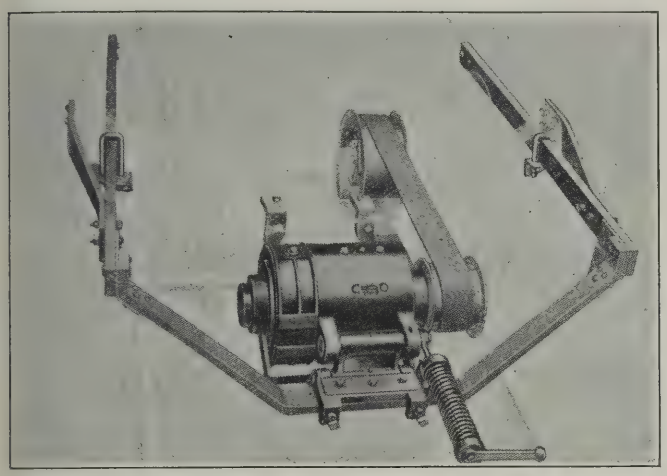


Fig. 5—End View of Truck Suspension Showing Pulley and Belt

generator lugs or on the supporting frame *B*, since the shafts are locked and cannot turn in the lugs or supporting frame; the turning motion being confined to the bushings in links *A* on the shafts.

This arrangement provides a parallel suspension with the points of support below the generator. A very important feature of this type of suspension is that it maintains constant belt tension, even when the belt stretches six inches. A tension spring bracket is bolted to the supporting frame and the tension rod *F* is secured

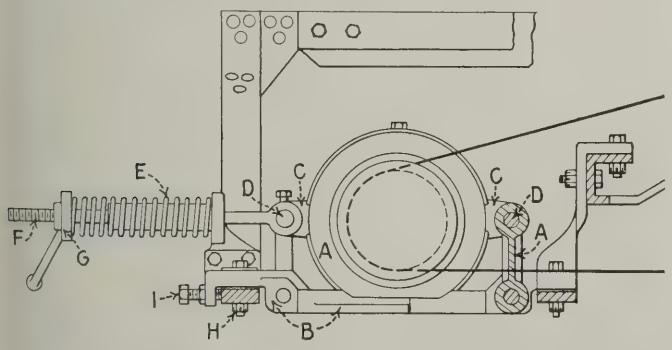


Fig. 6—Diagrammatic View of Truck Suspension

to the end of the shaft *D* with a tension spring *E* held at a proper predetermined tension by the nut *G*. Excessive belt strains, which are sometimes considered necessary to prevent the belt slipping when the tension decreases due to the belt stretching, are eliminated by this design. The nut *G* cannot be screwed beyond a predetermined position on the rod *F*, which limits the amount of tension an operator or inspector can apply. When the links *A* are in a vertical position the belt tension is due only to the pull of the spring *E*. If the belt is of such a length that the links are inclined away from the truck, a part of the weight of the generator is added to the belt tension, the amount depending upon the distance the generator is off the vertical. In moving the distance the tension spring is somewhat released and gives less pull. The design is such that the loss of tension in the spring is equal to the additional tension due to the generator weight, and the total tension on the belt remains constant. If the links are inclined toward the truck, the weight of the generator is subtracted from the increased spring tension, and the belt tension is still maintained constant. All parts of the suspension subject to wear are lubricated—grease pockets with felt retaining washers being provided for all such parts.

The arrangement for lining up the generator with the

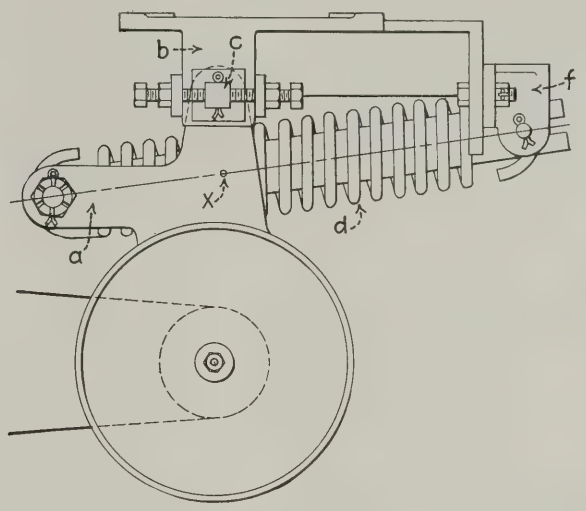


Fig. 7—Position of Dynamo When Distance Between Axle Pulley and the Suspension is Shortened

car axle is simple and easily operated. The supporting frame *B*, Fig. 6, is secured to the suspension irons by six bolts *H*. The center bolt on the front side, or side farthest away from the truck, passes through a round hole in both the supporting frame and suspension iron. The holes in the supporting frame for the other five bolts are slotted so that the whole frame *B* can be

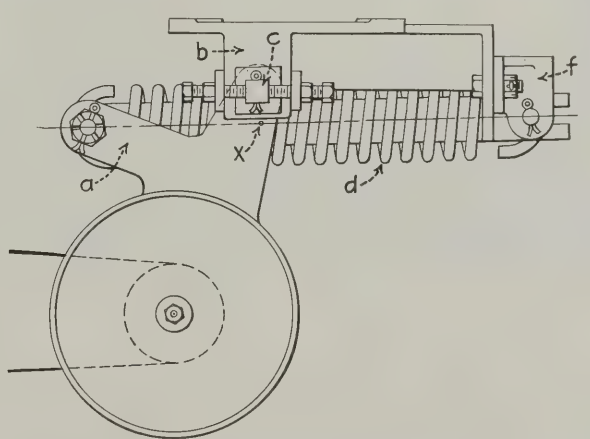


Fig. 8—Position of Dynamo When Distance Between Axle Pulley and the Suspension is Lengthened

swung around the center bolt. To line up the generator, it is only necessary to loosen all the bolts, line up the machine by means of the two adjusting bolts *I*, and lock it securely in position by means of the bolts *H*.

Inspection of the dynamo or removal of pulley, armature or heads, whenever necessary, is facilitated by the absence of long supporting bars giving clear

space around the generator as will be noted by referring to Fig. 5. In this illustration, it can be also noted that one side of the suspension is supported by a cross member fastened to side irons extending from the truck ends, while the other side is held by a bracket bolted directly to the end sill. This is a good arrangement, since the weight of the generator is distributed between the truck and side irons instead of having all the weight of the generator carried by the side irons.

Body Suspension.—A generator with a body type suspension is shown in Figs. 7, 8 and 9. Cast on the generator frame are the carrying lugs *A*, which are pivoted to the supporting lugs *B* on the suspension casting by the suspension bar *C*. The suspension casting is to be bolted to a suitable plate secured to the car body.

Belt tension is maintained by the weight of the generator and by the tension spring *D*, which engages at one end with a lug *A* on the generator frame and at the other end with the bracket *F*, fastened to the suspension casting. The parts are so designed that the sum of these two varying factors is constant.

When the generator is hanging so that its center of gravity is directly under the supporting bar *C*, as in Fig. 7, the weight adds nothing to the belt tension, but the spring *D* has its greatest effect, since the leverage on which the spring acts (the distance between *C* and *X*) is greatest. If the generator is swung, as in Fig. 8, the weight of the generator is giving tension, but the pull of the spring is decreased as the leverage *CX* is shortened; the sum of the two tensions being the same as in

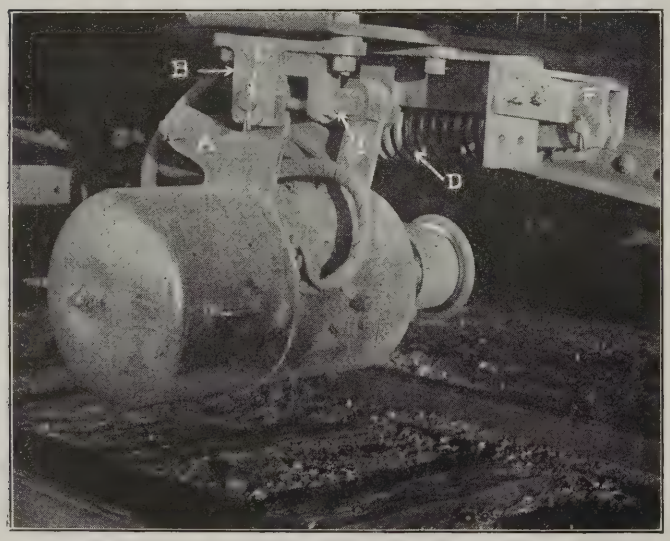


Fig. 9—Body Hung Generator

the first position. Ample latitude is provided between the two extreme positions of the generator, Fig. 7 and Fig. 8, to take care of belt stretch and the variation in distance between the dynamo and axle when the car is on a curved track.

The tension spring, Fig. 10, is assembled on a carrier, under the proper tension, so that to apply it to the suspension, it is only necessary to slip the pin secured to the lugs *A* through the hole *G*, and another pin through the hole *H*, and corresponding holes in the suspension bracket *F*. This gives ease of application and assures the constant tension.

The arrangement for lining the generator with the car axle is simple. The hole in one of the lugs *B*, Fig. 9, for the supporting bar *C* is slotted and the position of the bar can be adjusted and locked by means of the bolts *I*.

Fig. 9 shows the generator and suspension applied to a steel car and shows one simple method of attaching the suspension to the car, the clearance under the generator and its accessibility. This arrangement maintains the proper belt tension at all times and under all conditions and no adjustment of this belt tension device is required to maintain its proper operation.

The changing angle between the car and truck with this type of equipment as well as the variable distance

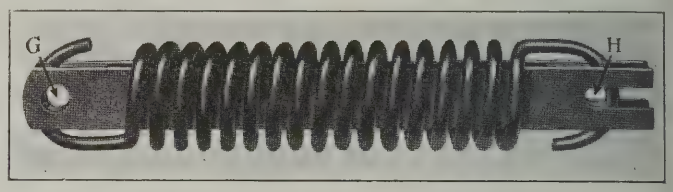


Fig. 10—Tension Spring Assembled on Carrier

between the centers of the car axle and the generator shaft caused by the car rounding curves, are adequately taken care of by maintaining constant belt tension with any position of the generator. This prevents excessive belt tension when the distance between centers is lengthened and eliminates belt slipping when the distance between the centers shortens.

Comparison

In striking a comparison between the truck and body suspensions, there are many things to be taken into consideration. Those who have studied the use of axle driven generators for car lighting, appreciate that the application of the generator to the car truck presents many problems, and that these problems are increasingly difficult to solve with the advance in design of steel trucks and car bodies. The deep center sill, almost universally used on new cars, has limited the space available for the application of the generator to such an extent that it is difficult to obtain proper clearance for the belt and generator, and frequently the generator is placed so near the track that ice and snow seriously interfere with its proper operation.

The rigidity of steel trucks cause wear of all moving parts of the generator and its suspension. The maintenance of these parts of car lighting equipment is becoming an important item in operating costs. Car designers would gladly welcome the removal of the weight of the generator, and generator suspension from the car truck, and would be glad to be relieved of the many other problems arising from truck suspended generators. These problems are directly responsible for the change of late years from truck to body suspensions.

A comparison between the body and truck suspension is very distinct in Fig. 11.

The body suspension has the advantage in that it removes the entire weight from the car truck. Of course, it is obvious that transferring the entire weight to the car underframe does not remove the entire weight from the truck, but distributes and absorbs it properly through the bolster springs. It removes the overbalancing weight from the car axle carrying the generator and suspension.

Fig. 11 shows the truck suspended generator very close to the road bed, where it is frequently hit by flying ballast and collects snow and ice. The body suspended generator here shown is so high above the track as to be out of all danger from snow and ice, and is also out of range of the dripping condensation from the traps on steam heating systems. It can be also noted that the belt clearance is increased in the body suspended generator. This increased clearance is between the belt and end sill or brake rigging. It is also a well known fact among maintainers that a body suspended generator can be renewed or applied to a car with much more ease than with the truck type.

Life of a Generator Belt

The life of a generator belt is governed by a number of factors, a few of which are track and weather conditions; size of pulleys, alignment of pulleys, and lost motion in running gear of cars.

Alignment of Pulleys.—The proper alignment of pulleys is a big factor in the performance of the belt. This holds good on both truck and body suspended machines. If the pulleys are out of line the result will be as follows:

1. Belt will ride over flange, become entangled with brake rigging and lost.

2. Belt will ride hard against pulley flanges and ravel along the edge, break back of fasteners and be lost.

3. Belt will ride flanges and slip back lengthwise to the face of the pulleys causing unnecessary wear and tear. on the belt fibres.

Lost Motion of Running Gears of Cars.—There is a certain amount of play between the various bearings and parts of the truck, and also in the movable parts of the generator suspension. This play will increase with the length of the service rendered by the car and in time, if not checked, will have a serious effect upon the life of the belt. The excess play will throw the pulleys out of line, the result of which has been given above. It will also vary the belt tension as the play is taken up and released by the action of the brakes. If this action releases the tension the belt will sag and strike the brake rigging and end rail, and if it increases the tension it is apt to snap the belt or break the fasteners.

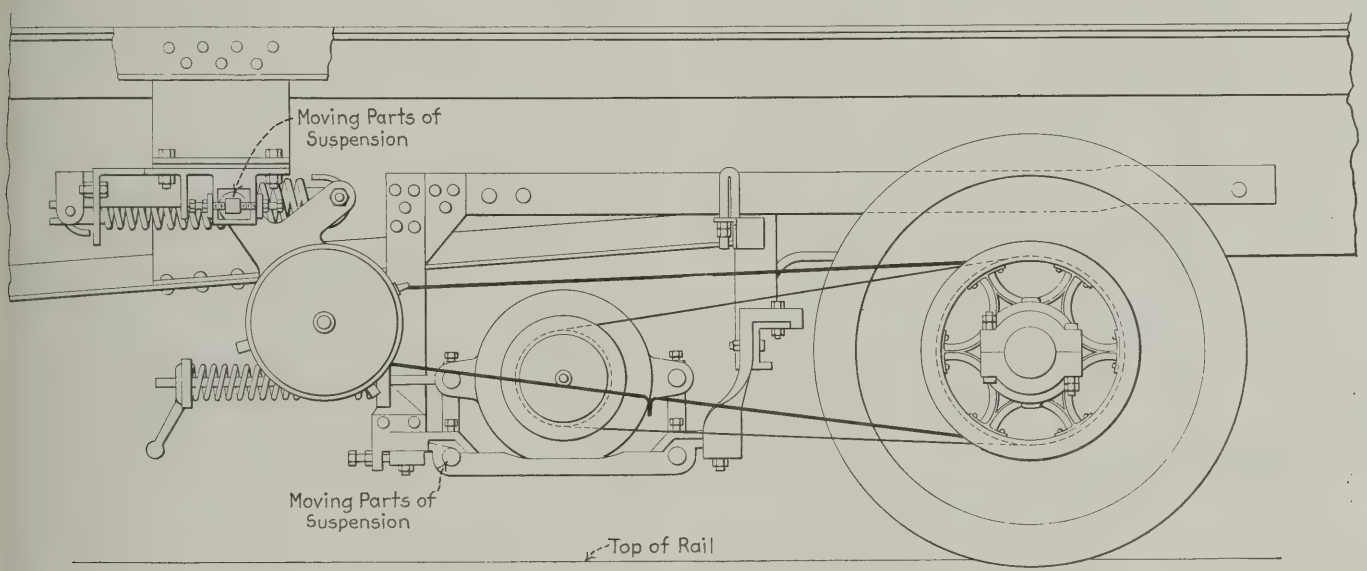


Fig 11—A Graphical Comparison of Size, Simplicity and Clearances Between Body and Truck Suspended Equipments

Track and Weather Conditions.—Track and weather conditions have a serious effect upon the life of the belt. Slipping of the belt is very often caused by the following:

1. Water sprayed from track tanks.
2. Steam escaping from steam drips.
3. Rain and snow.
4. Cinders and gravel embedded in the surface of the belt.
5. The action of hot and cold weather upon the composition of the belt.

Therefore, whenever the conditions cause the belt to slip, the heat generated by the friction of the belt on the pulleys injures the belt.

Size of Pulleys.—The smaller the diameter of the pulley, the less the area of belt contact, and the smaller the belt contact the greater will be the tension to transmit the same power. Also, the smaller the pulley the sharper the bend in the belt, and the sharper the bend, the greater the stress upon the fibre of the belt. Therefore the size of the pulleys has a decided bearing upon the life of the belt.

Maintenance

Considering the fact that a 15 ft. belt is worth approximately eight dollars, and a belt fastener is only worth fifty cents, it pays to examine the belt fasteners regularly and renew them when they are found to be defective.

Also it has been stated that the required tension depends upon the area of contact surface on the pulleys. Therefore, if the belt fastener is not applied at right angles to the edge of the belt, the point of contact will be at one end of the clamp and likewise the tension, instead of being distributed evenly along the clamp, will be centered at one end. Then as the tension is increased to compensate for the small area of contact the clamp will give way at one end and when this occurs, the belt will ride the pulley flanges and be lost. Therefore, it is of greatest importance that the ends of a belt are cut

square with its length and also that the fasteners are applied square with its length.

Calculating Speed of Axle Generators

In calculating the cutting in and minimum full load speed of an axle generator there are four things that must be considered, namely—

1. Diameter of car wheel.
2. Diameter of axle pulley.
3. Diameter of armature pulley.
4. Cutting in and minimum full load speed of the armature in r. p. m.

The cutting in and minimum full load speed of the armature varies with each type of equipment, and is easily obtained by applying to the manufacturer.

The following is one way to find the speed of the car in miles per hour, when the automatic switch closes.

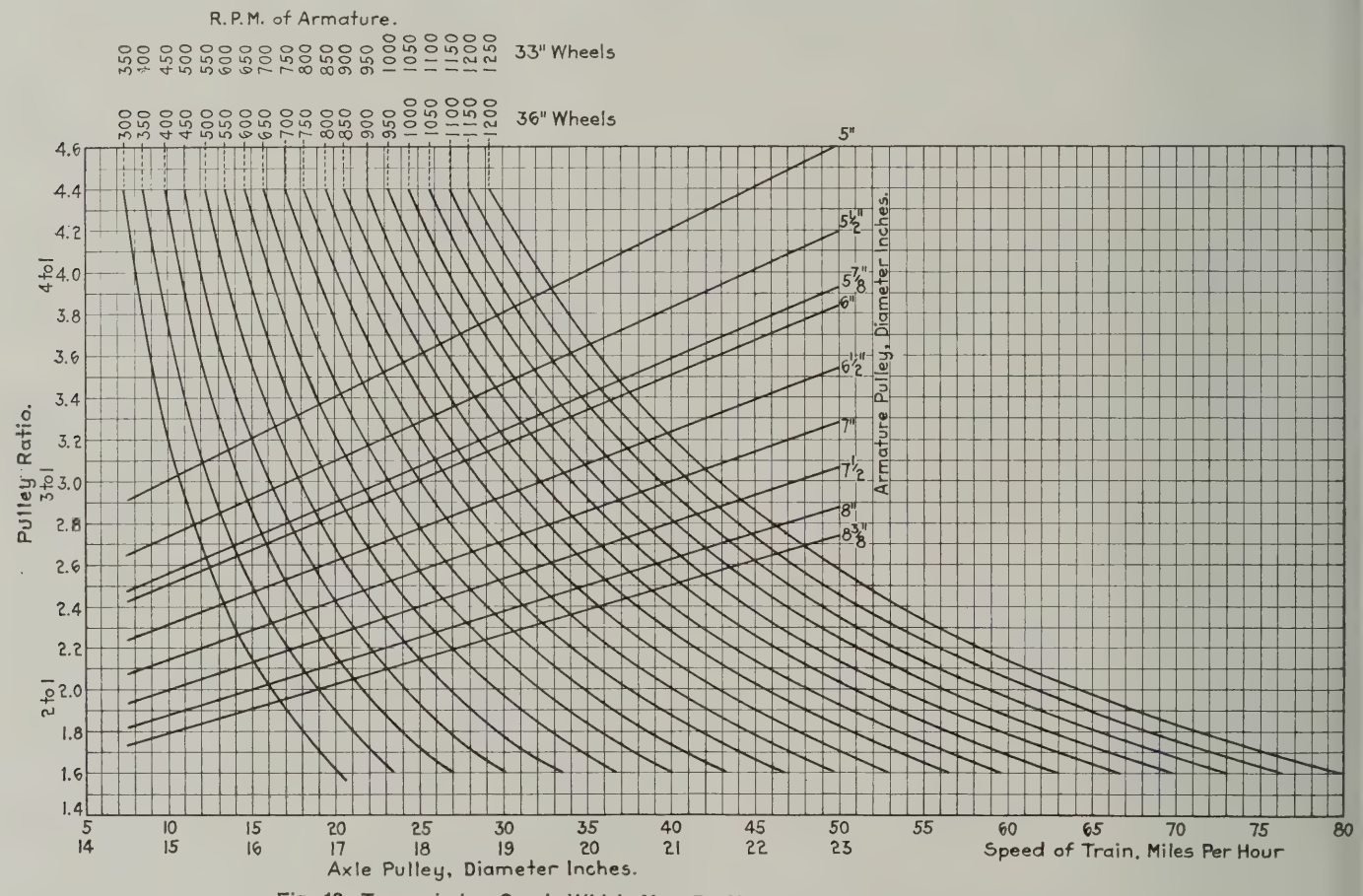


Fig. 12—Transmission Graph Which May Be Used to Determine Cutting in Speed

Knowing the r. p. m. of the armature when the automatic switch closes, divide it by the pulley ratio, that is, the ratio of the diameter of the axle pulley to the diameter of the armature pulley, and the result will be the speed of the axle pulley in r. p. m. when the auto switch closes. This value will also be the speed of the car wheel in r. p. m. because the axle pulley is bolted to the axle and rotates the same number of revolutions as the car wheel. Now, there are 60 minutes in one hour, therefore, multiply this value by 60 and the result obtained will be the speed of the wheel in r. p. h. when the automatic switch closes.

Next, multiply this value by the circumference of the car wheel in feet and the result will be the speed of the car in feet per hour. There are 5,280 feet in one mile, and this value can be changed to m. p. h. by dividing by 5,280.

For example, let us figure the train speed when the automatic switch closes (34 volts) on the following equipment:

Equipment—Type F2 Safety.
Cutting in speed of armature—250 r. p. m.
Size of axle pulley—18 inches.
Size of armature pulley—8 inches.
Size of car wheel—36 inches.
First step:
Pulley ratio is 18/8 or 2¼.
Circumference of 36 inch wheel is 9.425 feet.
R. p. m. of armature÷pulley ratio=r. p. m. of car wheel.
250÷2¼=111.1.
R. p. m. of car wheel x 60 min.=r. p. h. of car wheel.
111.1 x 60=6,666.
R. p. h. of car wheel x circumference of car wheel=speed of car in feet per hour.
6,666 x 9.425=62,827.
5,280 ft. per mile.
62,827÷5,280=11.9 or approximately 12, which is the speed of car in m. p. h. when automatic switch closes.

There is a much quicker method of figuring this, but more advanced. The easiest way of all is to refer to the transmission graph, Fig. 12. We figured above the cutting in speed to be 12 miles per hour. Now, if the cutting in speed of the armature were just double, or 500 r. p. m., the same car would be traveling just twice as fast, or 24 miles per hour when the generator cut in. Let us check this by referring to the transmission graph.

Find the 500 r. p. m. line in the 36 in. wheel column and follow this line to the intersection of the pulley ratio which is 2.25 and then downward. In the speed of train in miles per hour column, we find 24, which shows our calculation to be correct.

Relative Costs of Gas and Electric Car Lighting

ECONOMIC factors are not always the principal consideration in the selection of apparatus. Particularly is this true in railroad work where it is necessary to consider the safety and comfort of passengers. In the past many railroads decided to adopt electric lighting in spite of the higher initial cost of installation. The hazard due to the presence of gas tanks in the case of a wreck had its influence in their making this adoption, although this hazard is admittedly a minor one. Of greater importance are the ever increasing demands of the passengers, who now expect the lighting in railway coaches to be as good as they have in their own homes.

Efforts have been made from time to time to increase the quantity of light in the coaches. The introduction of the incandescent mantle allowed the use of gas to be continued for a certain length of time and not until the introduction of the metallic filament lamp was it possible for electricity to compete profitably with gas once more. The type C lamp now makes it possible, owing to its low power consumption, to obtain electric lighting with a lower operating cost than is possible with gas.

Comparisons between the cost of each type of lighting have often been made before, but such comparisons can only be reliable if they are supported by exact figures taken from the working statistics of the large railroad companies. It is moreover necessary that such comparisons should apply to the same type of coach, running under the same conditions and with the same quantity of light, and that each part of the whole expense incurred should be determined with the greatest possible care. Dr. Max Jakob of Baden, Switzerland, went to work in this way in 1914, and while reserving judgment on some of the results obtained by him, his general methods are adopted in the following:

The tests cover a distance of 62,000 miles at an average speed of 31 miles an hour. An allowance of 20 per cent, or 400 hours, is made to take into account stops at stations and termini. It is assumed that the coach is lighted during half of the total time, or 1,200 hours. A period of ten hours is also allowed as reserve lighting in the case of lighting with a dynamo and from 20 to 24 hours in the case of lighting with gas.

Cost of Installation

In each case the estimate of expense has been made in the following manner: In the case of gas the whole installation has been taken into account, as represented by the gas works with the necessary machinery for the manufacture of gas, the filling stations, the compression plant, the accumulator wagons required on account of the consumption of gas provided for the whole of the ground under consideration and the cost of fitting up the gas lighted coaches. All of these expenses have been calculated for one coach.

*A translation from Les Chemin de Fer et les Tramways.

As regards electric lighting, the expense per coach has been calculated in the same way. Straight storage systems are not included in the comparisons as their use has been practically abandoned and is more expensive than gas lighting. In both cases a rate of interest of 3¾ per cent has been taken which was the prevailing rate before the war.

Division of Costs

Total costs may be divided into interest and depreciation, upkeep and repairs including material and labor, cost of production of light and cost of coal to haul the extra weight of the equipment. Maintenance costs include general upkeep and repairs, cleaning, replacement of mantles in the case of gas, upkeep of the batteries and replacements of lamps and belts in the case of electricity, etc.

To arrive at the cost of production of light, a fixed price for gas was assumed as $3 per thousand cu. ft. Power required for electric lighting was translated into additional coal burned on the locomotive and the efficiency of the locomotive was considered to be 2.2 lb. of coal per horse-power hour. The weight of the apparatus was also taken into account and considered as 2,650 lb. in both cases. Knowing, therefore, the weight of the equipment, it was possible to calculate exactly the cost of haulage in each case. For this purpose, the figure of 13¼ lb. per ton was accepted as the average coefficient of traction. The initial cost of the gas lighting installation is $463, while the cost of electrical installation, Brown Boveri system, is $455. Depreciation in the case of the electric lighting equipment is considered as 3.85 per cent per year, while depreciation of the gas lighting equipment is considered as 2.85 per cent per year. The cost of upkeep, which reaches an average of $24.70 per car per year in the case of gas, is only $18.35 in the case of electricity. The cost of production of the light amounts to $33.55 for gas and $11.40 for electricity. The cost of coal required to haul the extra weight is almost equal in each case and varies between $14 and $15.

The total average cost for gas lighting is $93.15, while the total average annual cost per car for electric lighting is $79.10. These costs are itemized in the table.

Comparative Costs of Gas and Electric Lighting Per Year Per One Car

	Gas lighting	Electric lighting
Interest and depreciation	$30.40	$34.85
Maintenance	24.70	18.35
Cost of production of light	23.55	11.40
Cost of coal to haul the extra weight	14.50	14.50
Total cost per year per car	$93.15	$79.10

Conclusions

It may be said in a general way that the interest and depreciation costs of gas lighting are the lesser, but that the maintenance costs and cost of producing the light are less for the electric system. In view of the amount of the difference it would seem safe to say that good gas installations already existing should not be replaced except in a few special cases, and that for equipping new cars, axle-generator equipment should be used, even if for purely financial reasons. If the absence of danger, possibility of better distribution of light and comfort are taken into account, the case in favor of electricity is, of course, strengthened. These conclusions, although based on pre-war figures, still have their full comparative value.

Progress in Wiring

Some progress in inside wiring has been made during the last thirty years, but the progress has not been in keeping with that made in manufacture of apparatus and the generation of electricity, according to an opinion expressed by the wiring committee of the National Electric Light Association in its annual report presented in Chicago on June 1. This, the committee states, is particularly true in the United States, where the chief things that have been accomplished have consisted of the abandonment of some of the old and more dangerous methods, and improvements in the average quality.

The recommendations made and the opinions expressed by the committee are in substance as follows: "In grounded systems the neutral or grounded wire should be solid from the generator or transformer to the lamp except so far as regards switches that may be needed for testing purposes. There should be no fuse even on the grounded side of the two wire taps from three wire systems."

This should increase safety as well as reduce the cost of wiring by allowing the omission of fuses that are unnecessary and which introduce thereafter a distinct danger. There is a further possibility of saving by using less insulation on the grounded neutral wire, which will still leave the factor of safety far higher than the factor of safety now found satisfactory on the outer or potential wires.

Another improvement in wiring can be made by the fitting of the size of the wire to the maximum load rather than to a theoretical manufacturer's rating of the current using devices, a rating which is usually more than the actual maximum load carried by the wire, though in some cases it may be distinctly less.

This recommended practice is in opposition to parts of the present national code and in opposition to the present practice of some inspectors, and the committee does not wish to put itself in a position of conflict either with the inspectors or with the committee that draws up the national code, believing that the inspectors and others all honestly desire to have the best conditions possible. The recommendation is made, therefore, that all interested should, in co-operation with inspectors, arrange to get the special approvals needed in order to have as many installations made as possible in accordance with the methods outlined above. The results will be that in the course of time these better methods will become standard practice and will be submitted wherever conditions warrant.

National Electrical Safety Code

A third edition of the National Electrical Safety Code prepared by the Bureau of Standards, Department of Commerce, Washington, has been issued and is known as Handbook No. 3 of the Bureau of Standards.

The National Electrical Safety Code has been developed with the co-operation of representatives of all branches of the industry and the previous edition has become widely known as circular No. 54. This code consists of four main parts dealing respectively with (1) the installation and maintenance of electrical supply stations and sub-stations; (2) the installation and maintenance of overhead and underground supply and signal lines; (3) the installation and maintenance of utilization equipment; (4) rules for the operation of equipment and lines; and supplementary sections which include rules for protective grounding of equipment and circuits.

These rules have been adopted in whole or in part by a number of state commissions and they constitute a recognized standard for the prevention of accidents in the electrical industry.

The greatest changes made in the third edition of the code are in Part 2. The loading specification, upon which are based the requirements for strength of construction, has been simplified, and has been applied to signal lines crossing railways, for which arbitrary rules were formerly used. The rules have been rearranged in more convenient order, and an index has been added which greatly facilitates the location of rules on any given item. The sag tables have been extended to cover iron and steel conductors.

The new edition of these rules is in pocket size and has been entirely separated from the discussion of the rules which accompanied them in the second edition. This discussion has been considerably amplified and will be published separately as handbook No. 4, which is now in press. This handbook will be valuable in interpreting the rules and in making their intent and their justification more plain to the reader. The discussion constitutes a companion volume to the code itself, which should be secured by all those who have occasion to use the rules. Copies of handbook No. 3 may be secured from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Photo from Keystone View Co., Inc., N. Y.

A Landslide on the Central Railway of Peru

Standards to Determine the Strength of Welds

Bureau of Welding Committee Presents Report Describing Details of Tests Designed to Ascertain the Integrity of Welded Joints

THE desirability of having a satisfactory basis for the comparison and testing of the strength of welds is plainly obvious, and the recent report presented by the committee on Standard Tests for Welds to the American Bureau of Welding will be welcomed as a decidedly progressive step in the welding art. The situation is clearly outlined by C. A. Adams, director of the bureau, in a few introductory remarks, after which the committee report is given in full.

To the Welding Industry

We are submitting herewith specifications for Standard Tests of Welds. Standardization of the procedure in making a test of any kind is obviously necessary before results obtained by different observers can be compared.

The chief difference between testing a specimen of steel that includes a welded joint and testing an ordinary specimen is the non-homogeneity of the welded specimen. The welded specimen has its center, a section composed of material that usually has physical, chemical and metallurgical characteristics distinctly different from the adjoining metal. Furthermore, the section of the added metal is more or less irregular in shape and variable in size. Consequently, the procedure prescribed for testing of ordinary specimens is not applicable to specimens containing welded joints.

Differences in details of procedure have caused such widely divergent results that comparisons are frequently impossible, with the result that the usefulness of much of the research work on record is generally restricted, and in many cases the results are actually misleading.

Although more thorough research work in this field may develop more satisfactory standards for tests of welds, the need for some immediate standards is so great that the universal use of the accompanying specifications is urged upon all those who have to do with the testing work in this field. Criticisms and suggestions are invited. The present standards will be valid for a period of one year, and at the end of this period they will be modified if it is found desirable.

C. A. Adams,
Director, American Bureau of Welding

Report to the Bureau of Welding of the Committee on Standard Tests for Welds

The committee held a meeting on February 3, 1921, at the Engineering Building, New York. After some discussion of its two fields of activity, namely, preparation of standards for comparing welds and standardization of tests to be applied to welds in finished structures, it was concluded that (a) the Committee should first work on standards for comparing welds, and (b) the material prepared by a similar Committee under the Welding Research Committee of the Emergency Fleet Corporation, which was the result of a great deal of work on the part of several men, should be utilized as fully as possible.

The Committee in preparing the "Standards for Testing Welds," which are transmitted herewith, proceeded on three assumptions as follows:

1. The fundamental basis of measuring the effectiveness of a joint between two pieces of metal, is the same as metal without a joint. A joint is a necessary evil in a structure which is avoided when it is possible. Therefore, the value of a joint is best determined by comparing the characteristics of a section of the structure which includes the joint with those of a similar section which has no joint. In other words, a weld is a joint and the practical basis of evaluating a weld is in terms of the metal of the parts joined together.

2. Three standards are desirable, as follows:

(a) *Shop Standard.* In the shop a standard test is required for such purposes as checking the work of a welder from time to time, testing a new lot of electrodes in electric welding or of welding wire in gas welding, testing the effect of some change in conditions which may have taken place, etc. Such a standard must necessarily be as simple as possible and preferably a single test. The technique of the procedure in making the test must be of a simple character.

(b) *Commercial Standard.* There are many cases where more than one kind of test should be made, but where the circumstances do not justify a complete investigation. There is, therefore, a need for what might be termed a commercial standard for making, for example, comparisons between different commercial welding processes or between different kinds of electrodes in electric metal-arc welding or different wires in gas welding.

(c) *Research Standard.* When a complete investigation of a weld is to be made for research or other purposes, all tests and examinations are made which will contribute any information in regard to the characteristics of the weld. It may be necessary to make tests of a special character in special kinds of welds or where application under unusual conditions is contemplated, but there should be a standard list of tests which will give information which is complete as far as all ordinary requirements are concerned.

3. The details of the procedure in making the various mechanical tests should be carefully prescribed. It is believed by the Committee that standardization in this respect is of the greatest importance, because comparatively small differences in procedure have a marked influence in certain mechanical tests and unless these are eliminated the results are not comparable.

The Committee recommends that the proposed "Standards for Testing Welds" be adopted, at least tentatively, and be offered by the Bureau for general use. It may very well be that experiences will show the desir-

ability of making changes, but that can only be determined after the standards are in use.

Respectfully submitted.

W. J. Beck.
S. W. Miller.
R. E. Wagner.
H. L. Whittemore.
F. M. Farmer, *Chairman.*

Standards for Testing Welds

Note—These specifications are intended primarily to serve as a standard, uniform basis for testing and comparing *sample* welds as distinguished from welds in structures. The testing of the latter must necessarily be by non-destructive methods which would therefore be, in general, quite different from those employed in examining sample welds (test welds) made, for example, for the purpose of testing a welder's proficiency, comparing welding wires or comparing welding methods.

I. Definitions

The following are definitions of terms employed in this specification:

(a) A *Weld* is a solid union of metallic pieces formed by uniting or consolidating by hammering or compressing with or without previous softening by heat.

Note—This definition is quoted from the Century dictionary. It is the broad definition of a weld and therefore includes forge welding and resistance welding by either the butt or spot process. While these specifications are prepared specifically for fusion welds, it is obvious that some of the tests can be applied to other types of welds.

(b) A *fusion weld* is a weld formed by heating to a fluid state the edges of the pieces to be joined and allowing the metals to flow together (with or without additional molten metal being supplied) without any pressure being applied. The heat may be supplied by a gas flame, an electric arc, thermit or otherwise.

(c) In a fusion weld, the *base metal* is the material composing the pieces to be united by the weld. Unless otherwise expressly stated, it will be understood that a weld joins two pieces of identical material.

(d) In a fusion weld, the *weld metal* is the material which has been used in forming the weld. It may consist entirely of a base metal adjacent to the weld or of the material added to the fused base metal from a welding rod or electrode, or other material.

(e) *Filling metal* is the metal added during the welding process to form part of the weld. In gas welding it is supplied by means of a *welding rod,* in carbon arc by a *filling rod* and in metal arc welding by the *electrode.*

(f) A *test weld* refers to a sample of welding which has been performed under known conditions and upon which mechanical tests are to be made.

(g) A *test specimen* is a prepared piece on which a mechanical test is to be made.

II. Shop Standard

Bending test only.

III. Commercial Standard

(a) Bending test.
(b) Tensile test.

Note—It is probable that eventually it will be desirable to include a fatigue test when a method is standardized which will be suitable for commercial application.

IV. Research Standard

A. *Tests of base or parent metal.*

1. Chemical analysis. To include carbon, manganese, silicon, phosphorus and sulphur.

2. Mechanical Tests.

(a) Tensile. To include yield point, ultimate strength, total elongation and reduction of area.
(b) Bending.
(c) Fatigue.

3. Metallographic. Photomicrographs at 100 diameters.

B. *Test of weld.*

1. Mechanical tests.

(a) Tensile. To include yield point, ultimate strength, total elongation and reduction of area.
(b) Bending.
(c) Fatigue.
(d) Impact.

2. Metallographic. Photomicrographs at 100 and 500 diameters, respectively, at (a) the junction between the base metal and the filled-in metal, (b) the base metal adjacent to the junction, (c) the center of the filled-in metal.

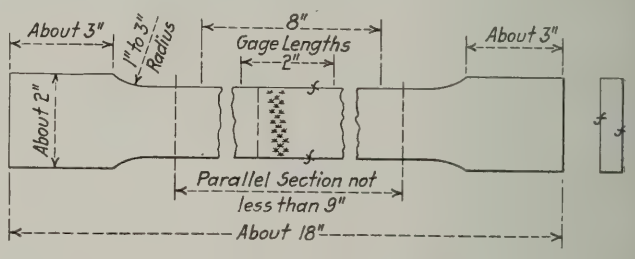


Fig. 1—A Test Specimen For Sheet Materials

C. *Tests of filled-in metal.*

1. Chemical analysis. To include carbon, manganese, silicon, phosphorus and sulphur.

2. Mechanical tests. Standard round specimens to be prepared from ingots deposited in a base-metal mould of such dimensions that normal cooling conditions will be approximated.

(a) Tensile. To include yield point, ultimate strength, total elongation and reduction of area.
(b) Bending.
(c) Fatigue.

3. Metallographic. Photomicrographs at 100 and 500 diameters, respectively.

V. Standard Procedure for Mechanical Tests

1. *Preparation of Test Welds.*

No detailed instructions for the preparation of test welds can be given as the dimensions, material, etc., will depend upon the purpose for which the weld is being made. The test weld should, however, duplicate as nearly as practicable, the commercial welds which it represents and should preferably be of such a size as to permit preparation of enough specimens from the one test weld to make all of the mechanical tests which are to be made.

When the test weld is made with material in sheet or plate form, the longest axis of the test specimen should, in general, be parallel to the direction of rolling.

2. *General Procedure.*

(a) Wherever applicable, the standard procedure of the American Society for Testing Materials as given in the A. S. T. M. for 1918 (serial designation E1-18) shall be followed.

(b) Three duplicate specimens shall be tested in

any one test and the average taken as the value of the property determined by this test.

3. *Tensile Tests, Base Metal.*

A. Test Specimens.

(a) Sheet or Plate Material. The test specimen for sheet materials is shown in Fig. 1. The thickness of the specimen may be any that is desired, but a thickness exceeding ¾ inch would require a testing machine in excess of 100,000 lb. capacity. If the specimen is cut from standard sheet material, it is usually not

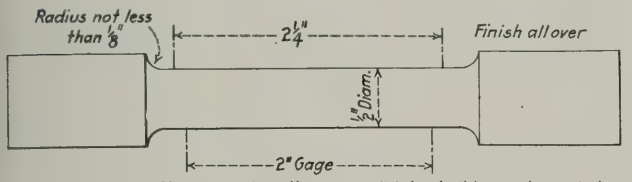

Radius not less than ⅛"
2¼"
Finish all over
½" Diam.
2" Gage
The gage lengths, Parallel Portions and Fillets shall be as shown, but the ends may be of any form which will fit the holders of the Testing Machine

Fig. 2—Specimen Used in Testing Cast or Brittle Materials.

necessary to machine the 1.5 inch faces of the specimen.

(b) Cast Material. The test specimen for cast or brittle materials is indicated in Fig. 2.* It is particularly important to use swivel specimen holders when testing such specimens in order to entirely eliminate undesirable stresses.

B. Test Results to be Recorded.

(a) Ultimate Strength. Unit stress (lb. per sq in.) computed from the area of the original section.

(b) Yield Point. Unit stress (lb. per sq. in.) at which marked increase in deformation of the specimen occurs without increase of load as indicated by a sudden dropping of the beam of the testing machine or by a sudden increase of the rate of elongation as shown by dividers.

(c) Contraction of Area. Expressed in per cent of the original area.

(d) Appearance of Fracture. The appearance of the fracture as determined with the aid of a low power magnifying glass (such as jewelers use) should be recorded. The characteristics described by the following nomenclature should be covered, indicating as far as possible the per cent of the total area which is involved. For example, "10 per cent not welded" would signify that approximately 10 per cent of the total area of cross section at the fracture is exposed base metal—that is, not welded.

Spongy: Full of small cavities; the structure resembles that of a sponge; porous.

Slag inclusions: Foreign matter entrapped in the weld.

Gas pockets: Small or large cavities, more or less isolated (*i.e.*, not of a regular spongy structure).

Not welded: Exposure of any portion of the surface of the base metal indicating imperfect fusion between the base metal and the filling metal.

Laps: Imperfect fusion between adjacent portions or between successive layers of filling metal.

(The recording of the following data is optional.)

*The diameter of this specimen may be 0.505 inch if desired. This diameter gives an area of exactly 0.200 square inch.

(e) Proportionality Limit. Unit stress (lb. per sq. in.) at which the deformation ceases to be directly proportional to the load.

Any type of extensometer may be used, but in precise work the deformations of two opposite elements of the specimen, preferably on the edges, should be obtained. For ordinary purposes deformations in only one element of the specimen need be measured, but in that case the gage marks should be on the centre of the line of the 1.5 inch side.

The gage length may be either 2 or 8 inches.

(f) Modulus of Elasticity. Unit stress (lb. per sq. in.) computed from data obtained from a specimen having an 8-inch gage length; measurements to be taken on two opposite elements, one on each edge of the specimen.

(g) Total Elongation. Gage marks shall be laid off every inch along a line at the centre of one of the 1.5-inch faces of the specimen before placing in the testing machine and the total elongation in every inch after rupture recorded. The total elongation in the 1-inch, 2-inch and 8-inch (if any) length, which included the break shall be reported.

4. *Tensile tests, weld metal.*

A. Test Specimens.

The shape and dimensions of the test specimens are shown in Fig. 2. It shall be prepared from a bar of *weld metal*, ¾ by 1 by 11 inches. This bar shall be formed entirely by depositing filling metal in an open box of the shape shown in Fig. 3, employing exactly the same method used in making the corresponding *test weld*. For metal electrodes this box shall consist

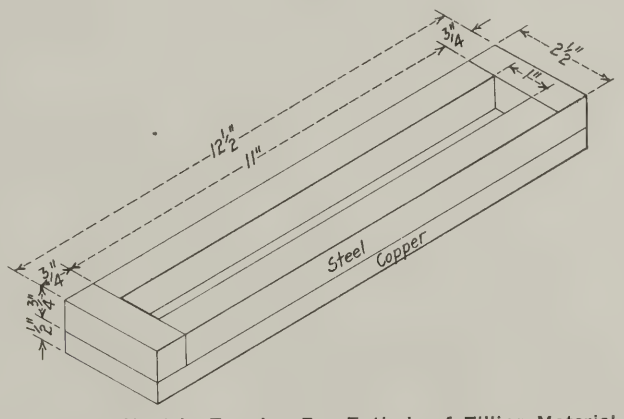


Fig. 3—Box Used in Forming Bar Entirely of Filling Material.

of a copper plate ½ inch thick, upon which is secured a frame of steel bars, ¾ inch square. The parts of the box was secured in any convenient manner. The copper plate, during this operation shall rest upon a steel plate. After the bar is formed, the copper plate and the frame may be removed by any suitable machining operation.

For gas welding, the copper plate should be replaced by a steel plate. For thermit, a box of suitable refractory material should be used.

B. Test Results to be Recorded.

These shall be the same as those prescribed in Section V, 3-B (base metal) except those involving an 8-inch gage length. If, however, the modulus of elasticity

is desired, a specimen similar to that shown in Fig. 2, with a gage length of 8 in. shall be employed.

5. *Tensile Tests, Weld.*

A. Test Specimens.

The shape and dimensions of the test specimen are shown in Fig. 1 with the weld at the centre. If the material is cast or brittle, the specimen shown in Fig. 2 shall be used with the weld located at the centre.

It is especially necessary that the 1.5-inch sides of the specimens be machined, particularly if the two pieces of base metal are offset or if they form an angle at the weld. Tests made in the latter case, where the specimens are not machined, are not reliable. Furthermore, care must be taken that specimens having the latter defects are not "straightened" before being machined, because such treatment is likely to materially decrease the strength of the weld. A roughening

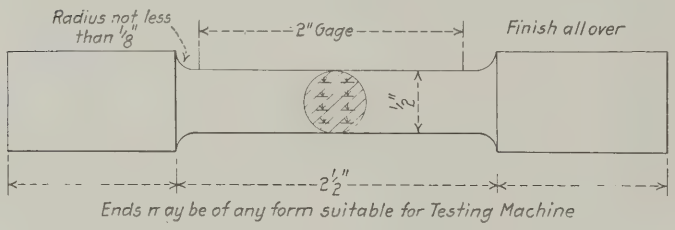


Fig. 4—Test Specimen of Round Cross Section.

cut in a planer or shaper which will just "close up" the surfaces of the specimen is sufficient.

B. Test Results to be Recorded.

The requirements for test results given in Section V, 3-B (base metal) shall be followed.

6. *Bending Tests, Base Metal, Weld Metal and Weld.*

A. Test Specimens.

(a) Base Metal and Weld. The shape and dimensions of the specimen are shown in Fig. 5.

In the case of welds in flat rolled material, the sur-

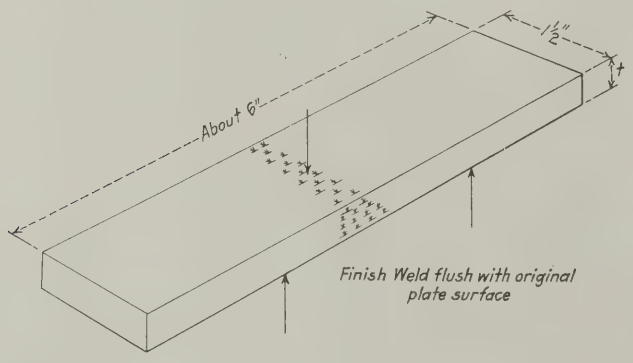


Fig. 5—Specimen Used for Bending Test.

face of the weld shall be machined substantially flush with the surface of the specimen unless the specimen is bent or offset, in which it shall be machined all over. Cast and other irregular specimens shall be machined all over. It is essential that the edges of all specimens be machined to remove material in a condition likely to cause premature failure.

The thickness, *t*, of a weld specimen shall be as nearly that of the base metal as possible.

(b) Weld Metal. A specimen may be prepared from a bar of weld metal prepared as prescribed for tensile tests. The box, Fig. 3, shall, however, have a width of 1.75 inches and the thickness, *t*, of the specimen shall be that of the test weld. These specimens shall be machined all over.

B. Apparatus.

In order to load the specimens so that as large a part of the bend as possible shall occur in the weld

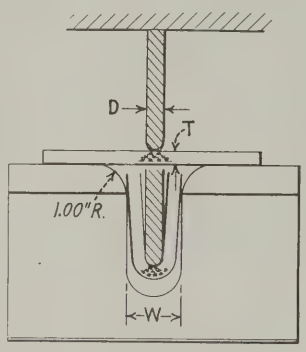


Fig. 6a

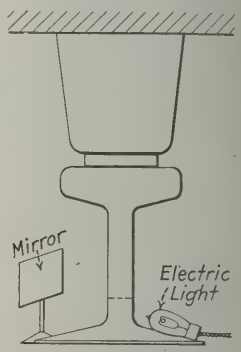


Fig. 6b

Figs. 6a & 6b—Sketches Showing Side and End Views of Apparatus Used in Making the Bending Tests.

metal, the special fixture outlined in Fig. 6a and 6b shall be used. It is most conveniently used with any standard universal testing machine, but may be operated by any other convenient mechanical means.

The cylindrical surface, D (Fig. 6a), about which the specimen is bent shall conform to the requirements of the American Society for Testing Materials for bending tests of the base metal.* This piece is attached to the under side of the moving head of the testing machine. Upon the platform shall be fastened two

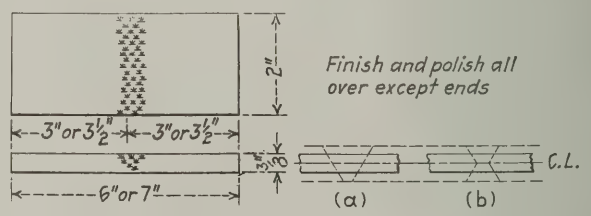


Fig. 7—Method of Preparing Specimens for Upton-Lewis Machine.

blocks having machined top surfaces and polished corners of radius, R, of 1.00 inch. These blocks shall be separated by a distance, W, equal to D plus 2 T plus ⅛ inch. A lubricant of lard oil and graphite or similar compound shall be used on these surfaces.

Two specimens shall be tested. The load shall be applied at the center of the weld—in one specimen to the open side of the "V" and in the other specimen to the closed side.

The rate of application of the load shall not exceed that at which the beam can be kept balanced at all times or a maximum of 2 inches per minute.

*For ship-plate steel (58000-68000 lb. per sq. in. tensile strength), it is "The test specimen shall bend cold through 180° without cracking on the outside of the bent portion, as follows: For material ¾ in. or under in thickness around a pin the diameter of which is equal to the thickness of the specimen; for material over ¾ in. to and including 1¼ in. in thickness, around a pin the diameter of which is equal to 1½ times the thickness of the specimen; and for material over 1¼ in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

The angle through which the specimen is bent may be measured by any convenient method. The following method is described as a matter of information.

A piece of paper is held firmly against the edge of the specimen when it is in place on the testing fixture and a line drawn on the paper along a corner of the specimen, thus outlining the shape of the specimen so far as bending is concerned. A line is drawn before

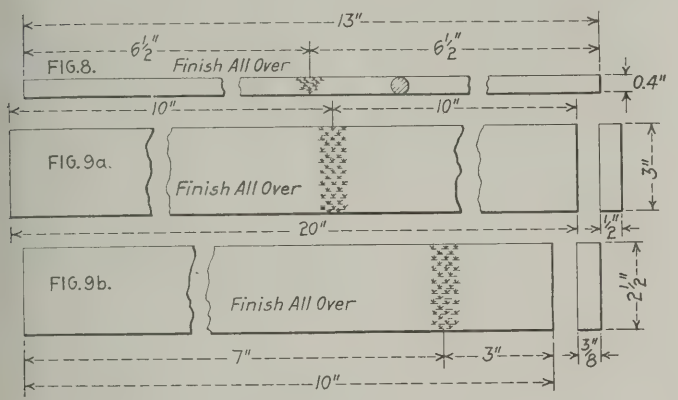


Fig. 8—Specimen Prepared for Testing in the Farmer Machine.
Fig. 9a—Type of Specimen Used in the Strohmenger Reverse Torsional Machine.
Fig. 9b—The Strohmenger Bending and Impact Machine Used Specimen with Weld Just Outside of Clamp.

loading and after failure occurs. The change in the angle in the two lines as determined with a draftsman's protractor is the angle through which the specimen had been bent at failure. See Fig. 14.

C. Test Results to be Recorded.

(a) The total angle through which the specimen has been bent when the first crack appears upon the convex surface (that is, the sum of the angles through

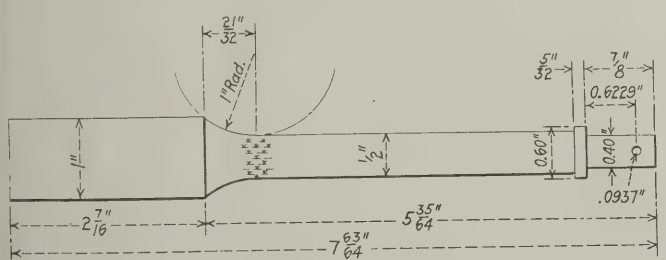


Fig. 10—Type of Specimen Used in the White-Souther Machine.

which the two halves were bent). To be measured without removing the load.

Note—An electric light and mirror will assist in observing this surface as indicated in Fig. 6b.

(b) The load on the specimen at which the first crack occurs.

7. *Fatigue Tests, Base Metal, Weld Metal and Weld.* There is no generally accepted unit or standard of comparison for fatigue tests so that the results given by the several machines which have been developed for such tests are not directly comparable. It is not practicable at the present time to recommend the use of any particular type of machine, and consequently test specimens are shown for all of the more common types.

Although in general, the results of fatigue tests are of maximum value only when compared with similar results obtained on the same machine, it is assumed that reference tests will be made on the base metal so that the results of tests on welds and weld metal can also be stated in terms of the results of tests of base metal. It is hoped that this will permit direct comparisons between tests made with different types of machines.

A. Machines and Test Specimens.

(a) General. For tests of weld metal it will be necessary to form a suitable bar in a box similar to Fig. 3, and having the proper dimensions.

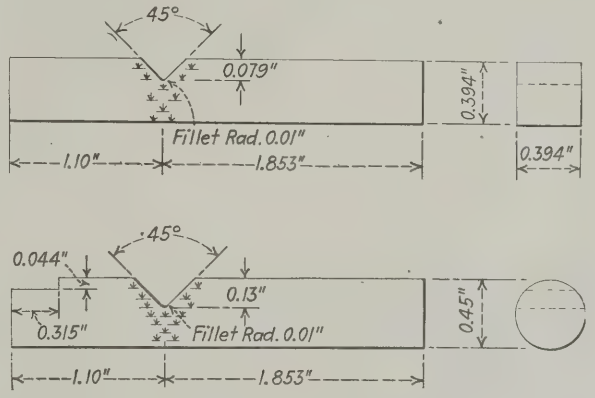


Fig. 11—Square and Round Specimens.

Fatigue test specimens should in general be machined all over (except the ends) and the surface carefully polished (preferably with the polishing marks parallel to the longest axis of the specimen). No. 1

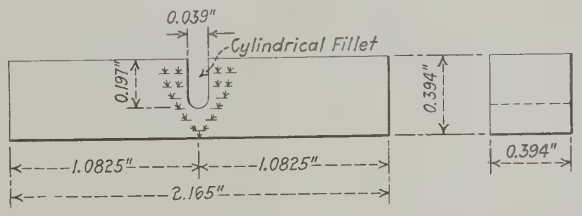


Fig. 12—Square Specimen for Cylindrical Fillet.

Manning emery cloth or paper or its equivalent will produce a satisfactory surface.

Provided the specimens are prepared from a test weld or other material of greater thickness than the

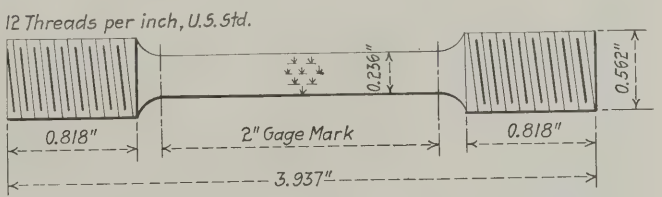


Fig. 13—Threaded Specimen With Weld in Center.

specimen, an equal amount shall be removed from both sides so that the specimen shall represent the material at the middle as indicated at a and b, Fig. 7.

(b) Upton-Lewis Improved Machine. This machine puts a bending load on the specimen which is reversed during each revolution of the machine. Specimen shown in Fig. 7. The distance between the jaws of the machine shall be ½ inch. If the specimen is a

weld specimen, the jaws shall be equidistant from the centre of the weld metal.

(c) Farmer Machine. This machine was designed specially for testing weld specimens. It tests the specimen as a simple rotating beam with free supports at the ends and two equal loads on a section at the middle. Specimen shown in Fig. 8. If the specimen is a weld specimen, the weld metal shall be at the centre.

(d) Strohmenger Reverse Torsional Machine. Comparative results only can be obtained, as there is no means of determining the stress. This machine loads the specimen in torsion, which is reversed for each revolution of the machine. Specimen shown in Fig. 9a.

(e) Strohmenger Bending and Impact Machine. Comparative results only. The machine strikes the specimen, which is held as a cantilever beam, bends it and releases it. This operation is repeated upon the other side of the machine. The weld, if any, is placed just outside the clamp in such a position as

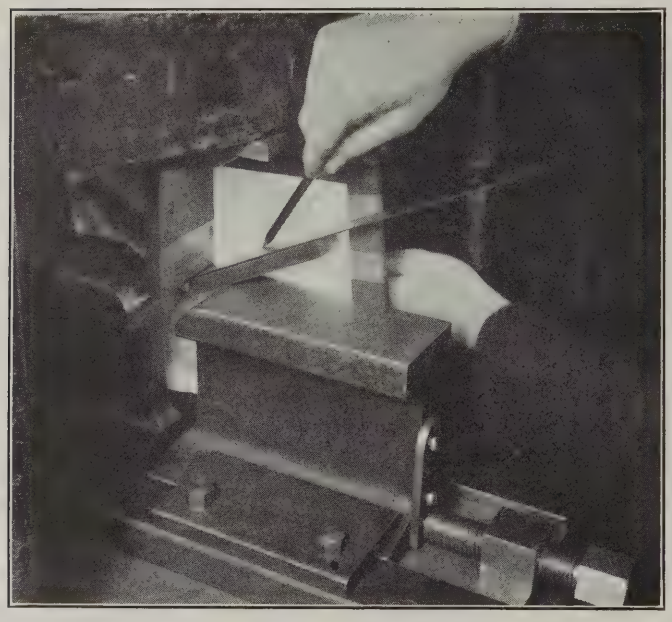


Fig. 14—Arrangement for Recording the Angle Through which the Specimen is Bent Before Failure.

to develop the maximum stress in the specimen. The specimen is shown in Fig. 9b.

(f) Moore Machine. This machine was designed for the Bureau of Standards for testing large size specimens of joints, both welded and riveted. It loads the specimen as a simple beam at the third point and the direction of loading is reversed for each revolution of the machine.

Specimens.—Any thickness not exceeding about 1 inch, with 8 inches, length 32 inches. If the specimen is a weld specimen, the weld metal shall be at the middle of the length of the specimen.

(g) White-Souther Machine. This machine loads each end of a rotating specimen as a cantilever beam. It is then rotated. The specimen is shown in Fig. 10.

B. Test Results to be Recorded.

(a) Number of cycles of the stress required to cause failure. A cycle is the period of time at the end of which the repetition of the variations of stress is begun.

(b) The stress developed in the specimen (if possible).

Automatic Telephones for New York

Before the end of this year New York City will probably have several new machine switching central offices. The first exchanges to operate by the new method will be Pennsylvania, Academy and Walker. This type of mechanical switchboard as adapted for use in New York city represents the results of years of investigation and improvement by engineers of the American Telephone and Telegraph Company.

The introduction of the new service into New York city will of necessity occupy a number of years. Wherever practicable it will be installed in all new central offices or wherever wornout equipment makes replacement necessary.

To make a call with the new machine switching telephones a subscriber lifts the receiver from the hook and a more or less mysterious mechanism at the central office gets into action, selects the subscriber's line and automatically connects it with an idle sender. When this is done the subscriber will hear a low humming sound called a dial tone, which indicates that the line is not busy and that the apparatus is ready to receive the call. By the use of the dial which is attached to the new instrument he may then dial directly any call other than toll or long distance, by dealing the first three letters of the central office name and the number of at least four numerals.

The actual electrical and mechanical means employed in completing calls are rather complicated.

In New York city there are over 900,000 telephone stations served from 101 central offices. Every one of these near-million stations can secure immediate connections with any one of the other stations and besides these local connections there are the thousands of long distance and toll calls involving extra charges, which must be cared for and recorded.

The demands for telephone service in recent years has been phenomenal. In the financial district of New York city these demands have more than doubled in the last five years. The telephone company is constantly adding to its huge system, enlarging existing buildings and erecting new buildings.

Photo by Keystone View Co.

Train Ferry at New Orleans

Safety in Relation to Electrical Appliances*

Protection is Relative and the Extent to Which it is Carried Depends Upon the Class of Persons to be Protected

THE subject of safety or of accident hazards with reference to electrical appliances is one which has received a great deal of attention in recent years but is new compared with the study of fire hazard of electricity.

The results of the study of accident hazards are embodied in the National Electrical Safety Code of the Bureau of Standards and the generally accepted code on fire hazards is the National Electrical Code of the National Board of Fire Underwriters.

The safety code is about four years old and the fire code is about twenty-four years old. Both codes are the result of years of study by all sorts of persons and associations and both are to be regarded as representing the best present consensus of opinion while being susceptible of further revisions in the light of changes in the art, the developments of invention and the accumulation of experience. The last edition of the Safety Code is that recently issued by the Bureau of Standards, the third edition dated October 31, 1920.

It is not our intention here to attempt a description of the history of these codes or of their contents. The purpose of this paper is to state the fundamental ideas of safety and accident prevention in the electrical field, to describe the general aspects of the problems involved and to illustrate some of these by reference to certain classes of appliances.

The uses of electricity are so numerous and the number of devices and machines employed is so great that anything like a complete discussion is manifestly impossible in a brief article.

Furthermore, the methods by which safety may be secured are matters of detail varying with the device, its location, size, method of use and the sort of person using it.

Electrical safety is an art rather than a science. It involves, as do all safety efforts, a large human element in addition to its economic and technical phases. What the employer *can* do and can pay for is one element. Habits and necessities of employees as well as their welfare must be given consideration. Perfection is unattainable even if it were quite possible that we could all agree what it is.

Electrical Accidents Occur in Two Ways

Electricity may cause accident in just two ways, by shock and by burns. To these must be added the mechanical causes of injury from moving machinery and the like which are possible in all apparatus whether electrical or otherwise.

Protection against shock is obtained by insulating current-carrying parts which may be touched, and the possibility that the insulation may at times be defective indicates the need of special precautions in some cases. Most power circuits are so arranged that some current will flow through a person touching live parts of them to the ground. By ground is meant not only the earth itself but any floor, pipe, wire or other conducting object in more or less direct electrical connection with the earth. Prevention of shock therefore requires that we consider such objects as possible paths for current at all times. Dirt and moisture increase the liability of such a path, being established for a dangerous current through a person's body.

The hazard of shock increases with the voltage. There are some well authenticated cases of fatal shock from a voltage of 110 volts, the usual lamp circuit voltage. The danger is believed to be small to persons in fair physical condition unless the contact made with the circuit is very good and long continued.

Two hundred and twenty volts is of course more dangerous. At 440 volts and over the hazard becomes very real and anything over 600 or 1,000 volts must be treated with respect and constant caution. It is not possible to say where real danger begins. By these voltages we usually mean in safety work, the voltage from the circuit to the ground and not the voltage across the two sides of the line, but this distinction is not uniformly made. There are no very reliable data as to the amount of current that will kill. This varies with the voltage. It at least appears certain that the killing current under most conditions and at common voltages is very small if measured in amperes, that is, small as compared with the currents taken by common devices, lamps, household and factory appliances. The amount of current sufficient to cause fatal shock is sometimes stated as 100 milliamperes at 600 volts.

The Practice of Grounding Circuits

Protective grounding is one of the chief methods of safeguarding electric appliances and is practiced in two general ways; first, by connecting one wire of the distributing system to the ground and secondly, by grounding the enclosures, frames and other metallic parts of equipment.

The grounding of the circuit has the effect of limiting the difference of potential (voltage) which can exist between other wires or connected apparatus and the ground. The exact conditions for grounding circuits and the methods of doing it should be studied in the two codes both of which deal with it. Grounding circuits is especially important when a normally low-voltage circuit such as 230 volts is exposed to possible contact at some points with a circuit of higher voltages. An ordinary type of transformer for alternating current power distribution receives power at 2300 volts on one of its windings and delivers 230-volt power from the other winding. A failure of insulation between these windings in the transformer or a cross between low and high voltage wires outside will impose the 2300 volts on the 230-volt wires and everything connected to them. Grounding the low-voltage side gives this high-voltage a path to ground where it is harmless. Evidently, the permanence and excellence of the ground connection are of prime importance

*Abstract from a paper presented before the American Society of Safety Engineers, New York, by Dana Pierce, vice-president Underwriters Laboratories.

and there should be no fuses in the ground wire to open up and remove the ground.

In years past, there has been no little objection to this has now passed and protective grounding of circuits is now very general and is being adopted rapidly in territories where it has not before been favored.

The city authorities and others in control of water companies long objected to grounded power circuits because of supposed injury to underground water pipe systems. More recent investigations have proved these fears almost wholly unnecessary and the former objections are now rarely made.

It cannot be too clearly stated that the proper grounding of power circuits under all conditions requires skill, experience and thorough knowledge of electrical power theory and operating. Correctly done grounding of circuits is one of the chief safeguards at our disposal.

The protective grounding of enclosure frames and the non-current carrying metal parts of equipment is a simple matter. In general, its purpose is to prepare in advance a current path to the earth so that in the event of the failure of insulation making the enclosure "alive" the current may have a route to ground other than through the body of a person. In other words, if a motor frame is connected to the ground, it will have the same potential as the ground on which a man touching it stands and therefore current will not pass to the ground through him.

Where such an enclosure cannot be grounded for operating or other reasons, then the man must be insulated by a platform, mat, gloves or some or all such means. Of the two general methods, the grounding method is the better where feasible.

There is one aspect of grounding enclosures, however, that is not always remembered. A switch in a grounded box is a case in point. If the use of the switch requires an operator to touch or come near live parts the proximity of the grounded box may actually increase his danger. If the box is closed and grounded, he cannot get hurt from it. Therefore, external operation of the device by an outside handle for instance, is a natural complement to the enclosing of the device.

For the purpose of protection against the other main direct hazard from electrical appliances, burning, the obvious recourse is to enclosure of apparatus in tight cases or their isolation to prevent approach to them when operating. To these, may be added the use of goggles and other protective clothing. In many cases, remote-control of switches and other current breaking devices lessens the hazard and these forms of appliances are becoming more and more general.

Accidents Other Than From Shocks and Burns

In addition to the hazards from shocks and burns as essentially electrical effects, we may briefly mention some other hazards which are of a more mechanical nature. On these, we quote from a recent safety standard of the Electrical Safety Conference.

Explosion of Fuses.—Fuses used to protect apparatus against overloads and short circuits, especially on large power circuits and with the apparatus near the generating station, occasionally explode with great violence. Such a condition is a possible cause of accident.

Gas or Dust Explosion.—Where apparatus is in an atmosphere containing certain quantities of inflammable gas, or inflammable dust or flyings, there is danger that an arc or flash at the controller may ignite this mixture, causing a fire and sometimes an explosion.

Moving Parts of a Controller.—Persons near apparatus may be injured by being struck by the handles or levers of circuit-breakers, and similar parts of the controller which may move suddenly and unexpectedly, unless these parts are properly located and guarded.

Phase Reversal.—With certain classes of machinery, such as elevators, cranes and hoists, the motor and load may not move in the expected direction with reference to the operating lever or handle of the controller because of an accidental phase reversal of the supply circuit. This may result in injury to persons because of unexpected direction of motion or confusion of the operator; it may in some cases result in failure of the limit switches and in injury to the machine itself.

Unexpected Starting.—Persons may be injured by moving parts of the motor or driven machinery, should the motor be started unexpectedly by another person, or by restoration of voltage after failure of voltage.

Over-Speed.—Motors and motor-driven machinery may run at excessive and dangerous speeds because of some change in operating conditions, such as—

(*a*) Separately excited direct-current motors losing their excitation.

(*b*) Series motors losing their load.

Lack of Emergency Stop at Point of Operation.—The operator of such machines as mixing rolls and calenders may be caught by the machinery and seriously injured if the machine is not immediately stopped by an emergency device.

Over-Travel.—Certain machinery, such as elevators and some hoists, unless stopped within certain limits may do serious damage to persons and to the machinery. Since the operator cannot be relied upon to stop the machine at the limits, some device, such as a limit switch, must be arranged to do so automatically.

Failure of Power.—Failure of power may cause injury to persons with such machines as cranes or hoists, unless the machine is equipped with a suitable device to stop and hold the load.

Current Overload.—Excessive current by overheating some part of the motor, controller or wiring may ignite nearby combustible material or so damage the insulation as to leave the equipment in a dangerous condition.

The Classification of Protection

In prescribing accident prevention rules for electrical apparatus, it is necessary to distinguish quite clearly several classes of persons to be protected and the methods employed must vary according to whether all of these classes or only one of them is involved. The classes may be named as follows: qualified persons, operators, and other persons.

By qualified person is meant one who is familiar with the construction and operation of the apparatus and who is assumed to have some appreciation of the hazards involved. Skilled electricians, inspectors, and other more or less expert persons may properly be included under this term. The ordinary shop foreman should not be considered a qualified person unless he has special knowledge of electrical matters and experience in dealing with them. The qualified person is supposed to be able to make inspections and adjustments of apparatus, to enter

rooms where high voltage equipment is installed, to open or remove enclosures for replacement of fuses, and in general to perform those operations necessary to the general maintenance of equipment. The qualified person, of course, is entitled to all the protection which the circumstances of his work permit but he cannot be protected under all conditions and a certain degree of dependence must be placed upon his individual intelligence, knowledge, skill and experience. Many of the safeguards which it is possible to place around electrical appliances will fail of their purpose if all sorts of persons are permitted to perform this special and more hazardous operation. Such qualified persons should have sole charge of the locks, rooms, guards, disconnecting switches and other protective devices. An ordinary workman should be prohibited from performing the duties of a qualified person. No safety program can successfully be carried out without constant attention to the human element and the distinction between the expert and the ordinary employee. The proverb that a little knowledge is a dangerous thing finds no better illustration than in the risks incurred by a person with imperfect knowledge of electrical affairs attempting to operate electrical machinery.

By operator we mean a person who is authorized to actuate or handle the equipment. He uses the equipment to run his machine and, as he probably knows little about the electric device, the protection afforded him must be more complete and be maintained more persistently than for the expert. He may properly open and close switches directly affecting his work but such switches should be so enclosed that he cannot expose himself to shock or burns.

He may be trusted to replace fuses only when provision is made so that he need not handle any live parts in so doing.

The third class of persons includes the ordinary workman or passerby who may inadvertently touch electrical apparatus or be affected by its failure in operation. As his attention will generally be on something else than the electrical devices and he must be assumed to have no appreciation of the dangers to which he may be exposed, we must guard against his injury even more carefully. Enclosures and the insulation of apparatus as far as practicable are in his interest.

When we attempt to provide protection, we may do it either by constructing each part of the apparatus so that it includes the necessary safeguards in itself, or we may remove apparatus which presents hazards or protect it by guards or gratings or by putting it in separate rooms. It is not necessary that the manufacturer of an electrical device should make it so that it can always and everywhere be used in safety. To do so would add an intolerable expense to equipment which would defeat the purpose. If apparatus cannot be placed so high on the wall or surrounded by guards and screens to make it safe, then, of course, the protective features must be built into the device itself. It is an economic question in every given installation how the results for safety may be secured with certainty by a proper combination of protection by construction and protection by installation. It is just here that the skill and experience of a safety engineer has one of its best opportunities.

The last few years have shown a very notable increase in the interest of manufacturers in providing safer electrical equipment. The old open knife switch is rapidly being displaced by enclosed or safety switches which are now available in a great variety of forms, many obtainable at a price so little above that of open switches as to make the use of the latter inexcusable except where, as on switchboards or other places, only qualified persons may approach or use them. Several of the larger companies are rapidly redesigning whole lines of switches, circuit breakers, motor controllers and other power apparatus to provide the safeguards prescribed by safety rules. In fact, it may be stated that one of the most strongly marked tendencies of present day electrical design is in this direction of safeguarding persons from injury. Like all movements for the betterment of society, this development is marked by animated and sometimes violent disagreement as to what is necessary and as to the rate at which progress can be made without imposing upon industry undue expense.

As applied to electrical equipments for ordinary houses, offices and other buildings than factories, the present tendency is strongly in the direction of so making and installing wires and connected devices that there will be no exposed live metal parts and no other metal parts liable to become alive which are not effectively grounded. Thus the present tendency is to ground fixtures to the conduits or other supports rather than to insulate them. The ordinary lighting panelboard formerly presented, when one opened the door, a mass of live copper parts, switches and fuses. The present safety panelboard shows only insulated handles and covers either of insulating material or of grounded metal. A wholly inexpert person can thus use them for ordinary purposes with practical safety.

In England, there has been some development in the way of grounding the outside casings of portable devices such as portable lamps, heaters and the like. While this is unquestionably a desirable thing from the point of view of safety, its practical accomplishment involves very real difficulties in changing American practice. It means that a third wire for the ground must be used, connected to the case of the appliance and at the other end to a permanent ground. Means must be provided to make sure that the ground wire is not confused with the circuit wire or worse results than in any ungrounded system may follow. The practical solution of this question of grounding portable devices has not yet been worked out except in a few instances. The suggestion has been made that metal cases be connected to the grounded wire of the electric circuit itself where there is such a wire but there are real objections to this both practical and theoretical. The present feeling is that the grounded side of the circuits should not be connected to exposed parts or depended on for grounding frames, sockets, casings, fixtures and the like.

Reducing the Electrical Accident and Fire Hazards

Some of the most important questions in electrical safety have to do with the installation and operation of power lines and connected outside apparatus but these are questions which it is impossible to discuss even briefly in a paper of this sort. The National Electrical Safety Code treats of them exhaustively.

State and municipal commissions throughout the entire country are interesting themselves more and more in safety rules for electricity. In several states, special codes have either been drawn up or are now in prepara-

tion. Some of these are combinations of the rules of the fire code and of the safety code. There is still much difference of opinion as to the desirability of attempting such a combination of rules. The Associated Manufacturers of Electrical Supplies, the Bureau of Standards, Electric Power Club, National Workmen's Compensation Service Bureau, and Underwriters' Laboratories have associated themselves in what is known as the Electrical Safety Conference and through special committees are developing a very useful set of detailed standards or safety codes for electrical appliances and systems. One such code, that on industrial control equipment, has been published and is now available for distribution. Other codes in process will cover enclosed switches, rotating machinery, switchboards and circuit breakers and other topics.

Underwriters' Laboratories is in constant relation to the various branches of the electrical manufacturing industry through its Industry Conference on which manufacturers are represented. The laboratories also cooperate actively on the committee work of numerous electrical associations and with state and municipal officers. Through these channels more and more work is being done in electrical safety and many intricate and difficult technical and economic questions involved are being worked out to a generally acceptable conclusion. The desirability of having tests both for fire and accident hazards conducted by properly qualified laboratories where experience and standards can be registered is evident and its utility is being daily demonstrated.

Changes in the electrical arts are so rapid that this work can never reach a final conclusion. New inventions, applications, and methods appear daily. Electrical energy is being utilized each year in even wider fields and is affecting interests of more industries and of more people. Electricity can be made safe and it may fairly be claimed that the developments in safeguards are keeping well up with other developments in the art. The extremist who demands immediate perfection has not yet reached his goal in electrical safety affairs any more than in any other human relations. He serves a useful purpose in pointing out the road but his ideas must be supplemented by the constant level-headed attention to details and to the practical limitations imposed by questions of cost and of habit. Perhaps we may say that the ideal safety engineer is the man who combines an ardent enthusiasm for perfect protection of his fellows against the accidents of life and work with a sound knowledge of the principles of science and its practical applications and utilizes them both with common sense.

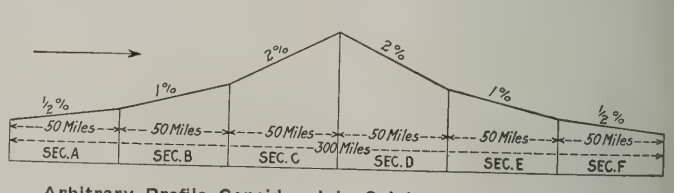
Fundamentals of Rational Electrification

An Example Showing What Factors Should Govern the Adoption of Electric Operation on Heavy Grades

By George R. Henderson

THE financial condition of the railroads in this country makes every economical suggestion of more than usual interest, and especially is this true of electrification, although the expense of installation at this time is, in many cases, prohibitive. A few years ago mechanical engineers received the unlimited claims of the electricians with considerable skepticism, but since a number of roads have electrified sections of their line and more rational claims are now in order, the subject has become one of importance to all the large roads.

A few weeks ago, at the Franklin Institute, in Philadelphia, A. H. Armstrong, of the General Electric Company, gave a most interesting lecture on this subject, presenting facts and figures which had been obtained largely from the Chicago, Milwaukee & St. Paul line in Montana, of which 440 miles have recently been electrified, and as this represents main line operation in a mountainous country, the results are of more general interest than those of local applications, such as the New York Central and the Pennsylvania in the vicinity of large cities. Mr. Armstrong's claims were moderate and entirely free from the "cure-all" type which did more harm than good a few years ago. The important matter of repairs, inspection, turn-arounds, hostling, etc., were presented so forcibly that the writer considered it would be of interest to compare the costs of steam and electric operation over a hypothetical mountain division and to discover what importance the cost of coal assumes in the discussion. As present figures for material and labor are considered abnormal, pre-war prices were assumed, such as those prevalent a dozen years back. A division of 300 miles in length with 50 miles each of ½ per cent, 1 per cent and 2 per cent up and down grades was



Arbitrary Profile Considered in Solving a Typical Problem

used as a basis of calculations, and is shown in profile by the sketch. Roundhouses for steam locomotives, are located at each end of the profile and at points 100 miles from each end. Locomotives may be considered as the Railroad Administration standard Mikado 2-8-2 type with the following characteristics:

Tractive force	60,000 lb.
Adhesive weight	240,000 lb.
Weight engine and tender	500,000 lb.
Heating surface (water)	4,285 sq. ft.
Superheater surface	990 sq. ft.
Grate area	70 sq. ft.

A train of 63 cars of 50 tons total weight each, or 3,150 tons for the load back of the tender, will require

one engine for Sec. A; two for Sec. B; three for Sec. C and one for D, E and F down hill, the train being considered as operating in the direction of the arrow. The helper engines would start from the intermediate roundhouses and in order to operate return trains would make 200 miles and 100 miles respectively for 300 miles of through train, one engine being used as a pusher over sections B and C. We may consider the level resistance as 5 lb. per ton, so that the total train resistance may be taken as 15 lb. per ton for Sec. A, 25 lb. per ton for Sec. B, 45 for Sec. C, 35 for Sec. D, 15 for Sec. E and 5 lb. per ton for Sec. F, the minus sign indicating the effect of gravity to push the train ahead on the descending portion of the run. For the type of locomotive indicated above we therefore find the following conditions:

Sec.	Locomotive	Total train weight	Total resistance	Ratio to trac. force	Speed upgrade
A.....	1	3,400 T.	51,000 lb.	85%	15 m. p. h.
B.....	2	3,650 T.	91,000 lb.	76%	17 m. p. h.
C.....	3	3,900 T.	175,000 lb.	97%	10 m. p. h.

Down hill a speed of 20 m. p. h. may be attained and perhaps 30 m. p. h. permitted on Sec. F. These speeds, with two hours allowance for changing engines, water stops, etc., would indicate a total of 20 hours over the 300 miles. Transportation delays, of course, would often increase this time.

The amount of coal has been estimated at 3½ lb. per horsepower-hour, which corresponds with 100 lb. per square foot of grate per hour for sections A and B, and 4 lb. per horsepower-hour for Sec. C. Down hill ¼ ton of coal per hour has been assumed. This gives coal used as

Sec. A 12 tons burned in 3 hrs. 20 min.
Sec. B 20 tons burned in 3 hrs. 0 min.
Sec. C 45 tons burned in 5 hrs. 0 min.

Down hill movement would use about 4 tons. The cost of coal varies greatly, especially at this writing, but some years ago $2 would represent a fair price per ton. The cost of pumping and treating water is likewise variable, but 25 cents per 1,000 gal. may be assumed, and as roughly one pound of coal will evaporate one gallon of water, we may charge water costs at 50 cents ton of coal.

Repairs constitute another variable, but 20 cents per engine mile would probably represent pre-war figures for a locomotive of this size.

The pay of enginemen (engineer and fireman) will be covered at the rate of 8 cents per mile, that is, $5 for engineer and $3 for fireman per 100 miles.

The cost of handling at terminals, including hostling, turning, wiping, inspecting, etc., will be taken at $1.50 per engine, and these various figures will be compared with estimated costs of electric operation. The coal consumed at terminals is not included, but would be considerable—on the other hand, the power plant for generating the electric current must be kept constantly in operation and a loss of some fuel must here be apparent.

The comparative costs for electric operation will consist largely in fuel and operating methods. For the locomotives we may consider a total of 12 pairs of drivers with 60,000 lb. on each and four truck wheels with 45,000 lb. on each, a total of 900,000 lb. or 450 tons and with train of 3,150 tons, we have a total of 3,600 tons. Whether satisfactory results could be obtained by using this tractive force of 180,000 lb. at the head of the train would depend upon the construction of the cars placed in this service, and it might be necessary to have one unit at the head and another at the rear of the train to prevent destruction to draft rigging and center sills. If the latter course were necessary, two engine crews would be needed, whereas one crew (of two men) could operate both units at the head of train by multiple control. The question of fuel will also depend upon the possibility of using regeneration, which means that there must be an ascending train at the same time that one is descending the grade and this may not always be possible of arrangement. If the power house is steam operated, a kilowatt hour could readily be produced at the switchboard by the combustion of 2½ lb. of coal, and if 25% loss be allowed from switchboard to rims of drivers, we will have a total coal consumption of 2½ lb. per horse-power-hour. The train need not be broken (except for the possible shifting to the rear unit in passing over the heavy grades), as the electric locomotives can run 300 miles without difficulty, whereas we have considered that the steam locomotives would have to lay over each 100 miles of upgrade. This will reduce the terminal expenses and as repairs are generally found to be less than for steam locomotives, they are taken at one half the amount, or 10 cents per mile for each of the two units. If the road was constructed as an electric line the intermediate roundhouses, with the coal, ash and water arrangements, shops, etc., could be eliminated, thereby saving considerable initial expense. Electric locomotives operate satisfactorily on inspections made every 3,000 miles and while they are much more expensive to build than steam locomotives, the fact that a greater car mileage can be gotten from them under ordinary conditions puts the initial cost of engines to about the same figure. The alternating current locomotive runs at a nearly constant speed, regardless of the load so that we may assume 15 miles per hour throughout, or 20 hours to pass over 300 miles. In the subjoined table, two columns are provided for the electric operation, the first considering that regeneration is not possible and that one unit of power must push over the 2 per cent grade; the second utilizes the force of gravity of the descending train to assist those ascending, and virtually to put coal back into the bunkers; also considers that one engine crew only is needed by putting all the power at the head of the train. By calculating the horse power needed to operate the 3,600 ton train, we find the fuel required as follows:

Sec.	Horse power required	Fuel required
A	2,160	9.5 tons
B	3,600	15. tons
C	6,500	28. tons
D	—5,000	—20. tons
E	—2,160	— 8.5 tons

The minus signs are the credits to be allowed where regeneration is possible, and would reduce the coal requirements from 53.5 tons to 25 tons. These various values may now be tabulated for comparison, remembering that the second electric column includes regeneration and multiple unit control.

Items such as train crew, car repairs, etc., which would be the same in both cases, have been omitted. It is evident from this table that the economies of electric operation should be considerable and must depend largely upon the original cost and fixed charges as well as the traffic conditions of the section. From the statements of Mr. Armstrong, the pre-war costs would have

been something like $30,000 per mile of road for electrification, and in order to save 10 per cent of this, there would have to be earned $3,000 a year over steam operation. By the first column of electric operation, there would be a saving of 59 cents per train mile, which would require over 5,000 trains a year or seven trains a day in each direction of 63 cars each, a total of 882 cars to pass over the division in each 24 hours—if the traffic did not approach this figure, electrification could hardly be considered. Then a variation in the cost of fuel might change the conditions enormously so that the saving would be greater or less than expected. If water power were available the cost of electric operation would be much more stable, but in any event each case would be a problem of its own and a careful study of all the conditions involved would be necessary to estimate the probable economic advantages which might be obtained. The above is simply a hypothetical case developed to show some of the possibilitites existing in a consideration of rational electrification.

	Steam	Electric 1	Electric 2
Cost of coal per trip @ $2.00.	$162.00	$107.00	$50.00
Cost of water per trip @ .50.	40.00	.....	.....
Cost of repairs per trip.....	120.00	60.00	60.00
Cost of handling.....	9.00	1.00	1.00
Pay of enginemen.....	48.00	32.00	24.00
Total per trip.....	379.00	200.00	135.00
Cost per train mile.....	1.26	0.67	0.45
Saving per train mile.....	.....	0.59	0.81

Electricity for Steam Locomotive Headlights

Equipment Needs Standardization and More Uniform Maintenance Methods Should Be Established

By A. H. Candee
General Engineering Department, Westinghouse Electric & Manufacturing Company.

AT a general session of the Interstate Commerce Commission held in its offices in Washington, D. C., on the 26th day of December, 1916, it was ordered that rules No. 29 and No. 31, of the rules and instructions for inspection and testing of steam locomotives and tenders, were to be as follows:

LIGHTS

29. *Locomotives Used in Road Service.*—Each locomotive used in road service between sunset and sunrise shall have a headlight which shall afford sufficient illumination to enable a person in the cab of such locomotive, who possesses the usual visual capacity required of locomotive enginemen, to see in a clear atmosphere a dark object as large as a man of average size standing erect at a distance of at least 800 feet ahead and in front of such headlight and such headlight must be maintained in good condition.

Each locomotive used in road service, which is regularly required to run backward for any portion of its trip, except to pick up a detached portion of its train or in making terminal movements, shall have on its rear a headlight which shall meet the foregoing requirements.

Such headlights shall be provided with a device whereby the light from the same may be diminished in yards and at stations or when meeting trains.

When two or more locomotives are used in the same train, the leading locomotive only will be required to display a headlight.

31. *Locomotives Used in Yard Service.*—Each locomotive used in yard service between sunset and sunrise shall have two lights, one located on the front of the locomotive and one on the rear, each of which shall enable a person in the cab of the locomotive under the conditions, including visual capacity, set forth in Rule 29, to see a dark object such as there described, for a distance of at least 300 feet ahead and in front of such headlight; and such headlights must be maintained in good condition.

The commission also ruled that all locomotives were to be equipped in this way by July 1, 1920.

This ruling revolutionized the entire locomotive lighting scheme. As the electric headlight is the only one which will satisfactorily fulfill all of the requirements, it became necessary to install a generating unit on each steam locomotive. Then, with electric power available, its use for gage lamps, cab lamps and lubricator lamps was logical, and followed out the commission's further ruling in regard to cab lights.

In general, each steam locomotive carries the following electrical equipment:

1—turbine generator of 500 watts capacity.
1 (or 2)—headlights with parabolic reflectors.
1—headlight switch.
1—dimming switch with resistance.
1—cab lamp switch.
Lamp, sockets, fuses and details.

Several Types of Equipment Available

There are on the market, at present, at least nine different types of headlight generators, each with entirely different characteristics. It is surprising that the various manufacturers differ so widely in machines which are of such small capacities, such simple characteristics, and where reliability of operation demands the utmost simplicity and the use of the soundest engineering principles. Reviewing some of the differences, we find: that there are open and closed machines; sleeve bearing and ball bearings; grease lubrication and oil lubrication; piston valves, needle valves and ball valves; various types of governors, including a magnetic brake to dissipate the turbine power in the form of heat; built-up turbine bucket wheels and forged wheels; steam and electrical ends in one housing in some machines, while completely separated in others; armatures pinned to the shaft and armatures built on; a. c. generators and d. c. generators, permanent magnets and wound fields.

There is no doubt but that a number of these discrepancies will be eliminated as time goes on and more experience is gained, either by the manufacturers or through more rigid specifications by the railroads. Time, or the railroads, will also operate to reduce the excessively high maintenance costs now required for a number of these turbine generators. High maintenance costs on these units has been generally accepted as being a necessity up to the present time, but the performance of some of the generators recently brought out belie this condition.

The generator is usually mounted on the top of the locomotive just in front of the cab, so that the exhaust steam will not obscure the enginemen's vision. Some roads,

however, have placed this unit on the smoke box, just in front of the stack, the idea being to keep the lagging of the boiler free from all possible apparatus which would require removing before the lagging could be taken off. The big objection to placing the generator on the smoke box, however, is the excess temperature reached at times. This may be as high as 500 deg. F.

Equipment Should Be Simple and Easily Maintained

From an operating standpoint, it is desirable to have a machine which will run at least three months without any attention whatsoever, and which can be maintained and overhauled without removing from the locomotive. The machine which is simple and straightforward appeals most

Headlight Set Applied to Locomotive In Recommended Position Just Ahead of the Cab and a Little to One Side of Center

strongly to the maintenance man and as a consequence, will be maintained the best.

While opinions vary somewhat, the general tendency is toward the omission of the strainer from the steam line to the turbine. This strainer is considered a source of possible trouble, due to clogging. A well designed machine will permit scale to pass through without trouble.

Oil lubrication has been found superior to grease for ball bearings in this service. Grease has a tendency to pack along the sides of the balls and, as a consequence, the balls are only lubricated when the grease cups are tightened down, whereas with oil, the tendency is to creep into the ball race at all times. Grease also catches and holds any grit or dirt which may work its way into the bearing, while oil acts to wash the balls and races continuously and to keep all parts covered with a thin lubricating coating. When standing idle, this thin coating also prevents rusting and creeping over the surfaces by capillary action. The method of cleaning an oil lubricated bearing is very simple; the oil is drained from the oil well and the well is filled with kerosene. After the machine has been run for a very short time, the kerosene is drained and the machine oiled in the regular way.

The continued successful operation of any electrical machine depends, to a considerable extent, upon keeping the insulating surface clean. While locomotive generators usually operate at 32 volts (considered relatively as a very low voltage), this statement still holds true for these units. This condition leads to the natural conclusion that any electrical apparatus for steam locomotive application will operate better if totally enclosed to exclude steam, smoke and cinders, as the combination of these three causes a very heavy carbon deposit. Operating experience has also confirmed this fact and there seems to be a general tendency to standardize on a totally enclosed machine.

In regard to standardization of headlighting equipment it is interesting to know that committees of the American Railroad Association and the Association of Railway Electrical Engineers are now working in connection with the railroads and the manufacturers, on the problem of standardizing some of the details, such as: location and size of steam inlet; location of mounting feet; brush sizes, bearing sizes; lubrication, etc. This standardization work should be furthered to the fullest extent by all who are connected with headlighting equipment.

Most of the railroads have modified their old headlights, putting in new parabolic reflectors, an incandescent headlight lamp and a lamp to illuminate the locomotive number windows. Among the headlights on the market will be found both incandescent and arc lamps.

The switches for controlling the lights and for dimming the headlight are usually located just above and within easy reach of the driver's seat. This equipment is at times subject to rather strenuous abuse and must therefore be of very rugged construction. The writer's personal experience with these details on the road leads to the conclusion that there is still room for improvement, the addition of a "tell-tale" light on the headlight switch to indicate whether the headlight is "on," "off," or "dim," and by more positive means of identifying the "on" or "off" position of each switch.

Lower Maintenance and Better Operation by Fusing

One question, on which there are different opinions, is the desirability of fusing the generator circuit. While there are reasonable arguments against such practice, it is the writer's opinion that lower maintenance and better operation will result by the use of fuses. With a 500 watt generator the fuses will be of at least 15 amperes capacity, which means that such fuses are by no means too fragile for locomotive service and if properly located, will not be subjected to high temperatures from the locomotive itself. Fuses of considerably smaller capacities than this are in daily use on electric locomotives and other types of rolling stock. The immediate indications of trouble, due to a blown fuse, will result in such trouble being repaired at the earliest opportunity and thus save in maintenance. Without fuses, a generator may be subjected to heavy short-circuit currents for some time before being discovered, which will inevitably result in higher maintenance. The renewal of fuses should not be a difficult operation for men of the calibre required of enginemen.

Generators can be designed to stand a short circuit continuously. However, in doing this, something else must be sacrified, either power consumption, commutation or other electrical characteristics. From an engineering and an operating standpoint it is better to design the generator with the best electrical characteristics and use fuses to protect against accident.

The Interstate Commerce Commission's ruling on cab lights requires lights for the gages and lubricator and a cab light to permit the enginemen to read orders, etc. The gage and lubricator lights are usually left burning

at all times the generator is running, while a switch is used to cut out the cab light. It seems highly desirable to add another light to the circuit, this light to be placed just outside of the cab, up in the hood and so arranged as to illuminate the coal pile without interfering with the engineer's vision.

The necessity of a generator on a steam locomotive for lighting purposes opens the question of how many desirable applications may be made of electrical energy to the operation of auxiliaries, such as for varying the cut-off, reversing, train brakes, signalling, etc. It remains for the steam locomotive designer to make use of this versatile form of energy.

N. E. L. A. Electrification Committee Against Government Operation

GOVERNMENT operation of railroads was spoken of as a "dread palsy" and recommendations for the future were made in the report of the Committee on Electrification of Steam Railroads at the annual convention of the National Electric Light Association in Chicago on June 3. The first part of the report was given over to a history of the development of electric traction for railroad trains and the summary consisted of recommendations for the future affecting both the railroads and the people who are served by them. The following is the summary of the report:

"The transportation problem is of vital interest to all of the people, and it is important that it should have the loyal support and interest of all classes of citizens and their active co-operation, so as to obtain the most rapid transportation of freight and passengers in the most efficient manner and at the least cost. This can be accomplished by the constructive support of the legislative bodies and the investing public and by the support of the engineering talent of the country. The time is here when the railroads need the united support of all the people, so as to make use of the improved methods of utilizing the advances in the sciences and the arts, in order to give the people the best transportation facilities. This can only be accomplished, first, by legislation which will remove the objectionable restrictions in the management and operation of the railroads; and secondly by the financial support of investors, so that additional capital will be retracted to the railroads, to enable them to add to their facilities such plant and equipment as is necessary to take care of the increasing traffic and to handle this traffic in the most economical way.

"We believe that at this time much good can be accomplished by studies and investigations conducted by engineers of the railroad management who are well qualified by their training and experience to make these studies. They should have the active co-operation and assistance of the engineers representing other utilities and the large industries, and of consulting engineers who are specialists on this subject, so as to bring to bear upon this question the best minds available, in order to effect improvements in the terminal facilities, rights-of-way, motive power, and in the traffic of the railroads. The power companies of the country stand ready to co-operate in these studies, and to be prepared to offer electrical energy at low cost in most cases where it may be utilized to the railroads' advantage.

"Although the railroad situation is one of interest, and the railroads have had their large part in the development of the American nation, the situation in regard to their future is one of compelling importance. It is unthinkable that American transportation should be subjected to the dread palsy of government operation. We have just about reached the point (disregarding the present recession in business as temporary) where possible restriction to traffic movement in its limitations of industry, has become a matter of the greatest concern to large sections of the United States. There is probably no district or community which is willing to admit that its growth in industry should halt or be limited. For the country as a whole, the growth of industry and population has called for an increase in traffic movement of 100 per cent during each interval of approximately 12 years. While it is not certain that the same rate of growth will be followed during the next 12 years, the situation of the future is sufficiently grave to prove the necessity for provision of transportation facilities necessary to care for the vast increase in business.

While it is not our purpose to point the way out, there must, somehow, some way be developed to care for this situation. Undoubtedly, great good could come from education. The credit of the railroads must be established to provide the large amounts of capital necessary to develop the transportation machine. To that end, all practices, criticisms, legislative action, both national and local, which operate to affect the credit of the railroads, should, through education of the critics, be eliminated. In its stead, should take place discussion of the burdens of expense imposed upon the railroads by class legislation, unproductive improvements, unreasonable demands of one class of labor to profit at the expense of all other classes, along with the obvious education of the shipping and traveling public as to more economical practices in the movement of traffic.

The net result of these would be a sufficient margin between reasonable rates and cost of operation to secure a return which would attract additional capital necessary for the expansion of the railroad machine. There is no stronger force under our form of government than public opinion, and American public opinion in the final analysis has been proven to be reasonable. With the support of public opinion, therefore, upon such a program, the timidity of the investing public as to railroad securities would be removed and there should be available the necessary capital at reasonable rates of interest.

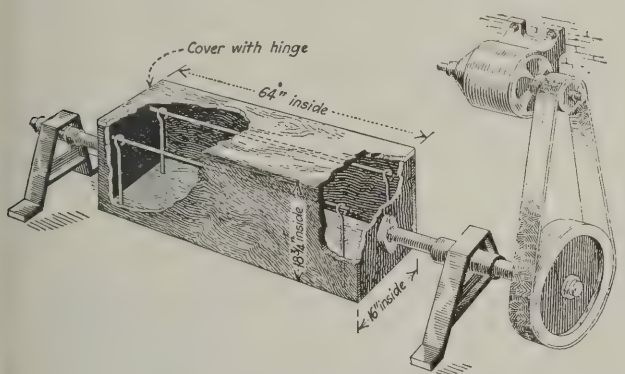
The National Electric Light Association, comprising in its elements a large and far-reaching body of intelligent men, should, prompted by their own interest in the expansion of all industry, accept and undertake as a real responsibility, the intelligent discussion and understanding of the needs of the railroads. Even if this view, which is a broad one, should be limited to self-interest, this should be prompted by the unquestionable fact that for the greater expansion of our railroad service, railroad electrification will come increasingly into use.

The City of Philadelphia adopted "summer time," which went into effect on June 6; and the railroads have prepared new time-tables so as to run suburban trains, and some others, one hour earlier than by the present time-tables.

Prolonging the Life of Edison Cells

It has been found that an old Edison cell which gives a low or reverse voltage reading may be brought back to normal by shaking it to loosen all detached material from between the plates. A writer in the *Electrical World* describes a contrivance for accomplishing this result. The apparatus consists of a revolving box driven by a motor. This box is constructed of 7/8 in. wood stock and is large enough to accommodate the largest tray used with Edison batteries. On the outside ends of the box are flanges holding two shafts which are supported in bearings bolted to the floor. On one of the shafts is mounted a pulley through which the box is rotated by a belt from the motor.

The process of restoring or rejuvenating the cell is carried on as follows: Half of the solution is poured out



General Arrangement of Rotating Box

and all the cells are placed in the tray, which is then set inside the box. Short wooden pieces are laid across the top of the tray and upon these are placed two pipes which extend the length of the box on each side of the tray. The pipes are inserted in hooks made of 5/8 in. iron, the ends of which extend through four holes in the bottom of the box. The lower ends of these hooks are threaded to receive large wing-nuts and when these are screwed up tight the tray itself is held firmly in place. After revolving the box for about ten minutes at a speed of about 50 r. p. m., the tray is removed from the box and the remaining portion of the electrolyte is poured out. Edison renewal solution is immediately afterwards put into the cells.

It has been found from experience that such treatment will frequently wash out and loosen the material which has short-circuited the plates, thus putting an old battery back into good condition.

Novel Storeroom Lighting

The difficulties encountered in illuminating the numerous small compartments contained in storeroom bins are readily overcome by following the scheme shown in the plan and photograph.

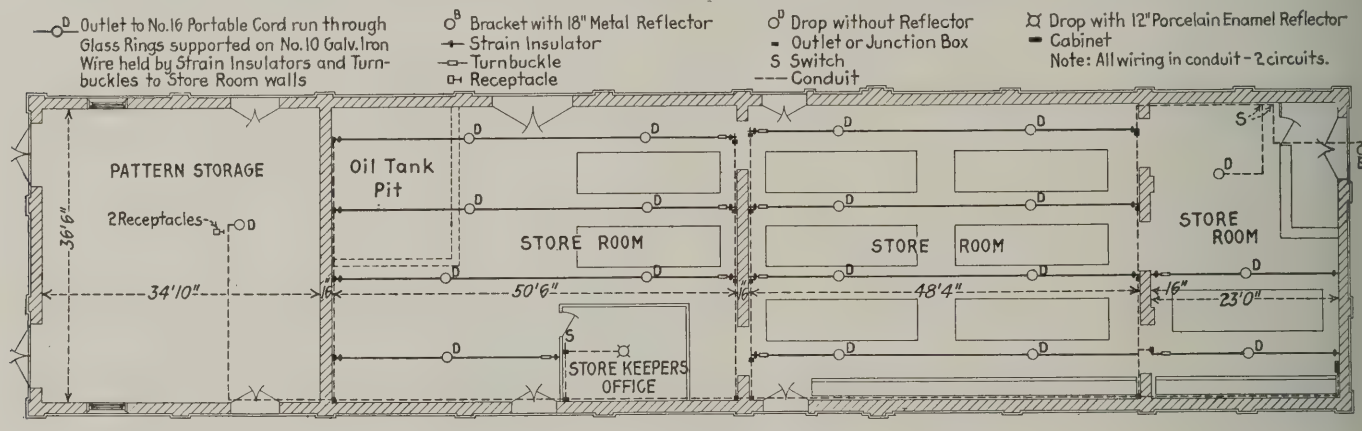
It is obvious from the photograph that the roof of the

Arrangement of Movable Drop Cord and Supporting Wire

storeroom is extremely high. If the conduits were fastened to the rafters and drops suspended, the cost of the wiring would be double that of the scheme adopted.

The building is wired in conduit in accordance with the National Electric Code. The conduits are fastened to the walls and enter outlet and junction boxes in the usual manner. The outlet boxes from which the portable ex-

tensions are carried are provided with standard metal covers with hard rubber bushings. The outlet boxes for the extensions are located on opposite walls near the ends of each trolley. The trolley is a number 10 galvanized iron wire fastened at both ends to the wall, strain insulators having been previously inserted. A turnbuckle at one end of each trolley provides for taking up the slack. Glass rings such as are used for operating awnings were slipped on the trolleys before they were fastened to the wall. Number 16 portable lamp cord passes through the glass rings, sufficient cord is allowed so that the lamp socket will reach the extreme end of the bin. One lamp



Plan of Storeroom Showing Location of Lighting Accessories

located between two bins serves to illuminate the small compartments in those bins. The lamp may be readily moved from one end of the bin to the other.

Constant slack in the portable cord between the rings is maintained by securing the cord to the glass rings at predetermined intervals by means of friction tape. Although lamp guards are not shown in the photograph these have since been applied.

The most prominent feature of this scheme is that there is no extension cord hanging in the store attendant's way and he can have the use of both hands after he has adjusted the location of the lamp.

A Man May Be Down

When Abraham Lincoln was a young man he ran for the Legislature in Illinois and was defeated. He next entered business, failed, and was seventeen years paying his debts.

He was engaged to a beautiful young woman—she died.

Entering politics again, he ran for Congress, and was again defeated.

He then tried to get an appointment in the United States Land Office, but failed.

He became a candidate for the United States Senate and was badly beaten.

He ran for Vice-President and was once more defeated.

When you think of hard luck, think of Lincoln.

—*The American Legion Weekly.*

Old Dr. Reason Prescribes

I've always liked Walt Mason's stuff. He picks a subject; treats it rough and with his hammer and his tacks nails down a lot of salient facts. I've found his old-time brand of booze can woo the same poetic muse: so I think I'll use this now and then, when the ink flows freely from my pen.

Adverse condition loudly cries, for us to all economize. To get together, buck the slump and save our railroads from the dump. The less you love your little job, the larger grows the idle mob. Unless you act, this term "adverse" will keep on getting worse and worse.

We had a war and all got stewed on "hootch" that Bill the Kaiser brewed, and in this wild and woolly brawl we got so full we couldn't crawl. We whooped her up and tore our shirt. We gave and spent "until it hurt." We tossed our dollars in the air and let them land most anywhere. When Fritzy took his final flop, us birds just simply couldn't stop. Now, sick and sore we go to bed and nurse an awful, awful head.

Old "Doctor Reason" comes to us, with all our belliache and fuss. He lifts our grimy, shaky paw and pumps the sludge from out our craw. Then seats himself upon

Money Mad

our bunk and analyzes all this junk. In a dim, mysterious, hazy way, we hear the old guy softly say:

"Collectively, I'll bawl you out; so in your mind there'll be no doubt as to the cause of all your pain and maybe you won't slip again.

"While Tom and Dick and Jim and Jud were 'over there' in Flander's mud, you stayed at home and copped the Kale, and some of you should be in jail. Devoid of reason, sense or fear, you helped along the profiteer.

The cost of things—that cut no ice—you bought and bought and paid the price. You sold your 'bonds' and hocked your 'stamps' and blew it in upon the Vamps. You could not sense these days so lean, when you were burning gasoline. When you were asked to please produce, you sputtered out, 'Oh, what's the use.' You loafed and stalled and dodged the boss and now have Economic Loss.

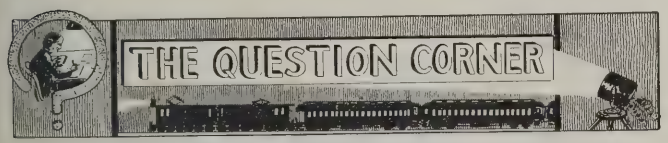
"You now stand by the River Styx and you are in some damn bad fix. You can't crank up the Henry now,

The After Effect

load in the children and the frau and wave a silk-cuffed hand at Fate as you sail gaily out the gate. The country's going on the blink; our ship of state is going to sink unless out of that cot you fall, spit on your hands and hit the ball.

"I spoze I'll have to help you live, so a simple powder I shall give. One-half of it is common sense; the other half is confidence. If you'll take this and really try, I think that you can still get by."

A man's popularity can be measured by his prejudices.



Answers to Last Month's Questions

1. *Why is it that manufacturers of lead storage batteries insist upon the use of distilled water in flushing the cells?*

2. *Two sets of batteries on the same train were flushed on the same date, but at the end of a month one set is down to the top of the plates, while the other set is still good for two weeks. If the lamp load is the same for both batteries, which set could be considered in normal condition?*

3. *If no fuses are blown and the belt is O. K. on an axle generator equipment that is not working, what is the first test to be made to locate the trouble?*

A. R. E.

* * *

1. The reason manufacturers insist upon the use of distilled water for flushing cells is that tap water may contain impurities which are harmful to the cell. Such impurities will lessen the capacity of the battery and ruin it. The electrolyte must be free from certain impurities such as chloride, nitrate, iron, copper, arsenic and platinum, although some impurities such as lead and calcium are not injurious.

2. If both sets receive the same charging, the low electrolyte in one set would seem to indicate excessive gassing, so I would consider the other set in better condition.

3. I would test for "open" or loose connections which may be anywhere between generator and starter.

A. H. M.

* * *

1. Distilled water is always free from impurities which are very liable to be present in practically all other kinds of water. Such impurities may not occur in large quantities and a single flushing of a set of batteries might not do particular damage. However, when the batteries are successively flushed with water containing impurities, even to a small extent, the total amount of foreign matter remaining in the batteries after many flushings becomes very appreciable and may be the result of permanent injury to the batteries.

2. In all probability both sets of batteries are being seriously overcharged. When a battery is overcharged it gases and the gas given off is nothing but the decomposed water. It would, therefore, seem that the batteries in question were being excessively overcharged and it would not be exactly proper to say that one or the other of the sets was the more normal. A battery which is operated without excessive overcharging does not require frequent flushing and may go as long as six months between flushing periods.

3. Since the belt is on and no fuses are blown it would seem that the trouble was either in the automatic switch or in the generator field circuit. The first test to be made would be to pull the main fuse and connect the lifting coil of the automatic switch to the battery to see if it closes properly. If it does, then look for open circuits in the generator field circuit. There may be an "open" in the carbon pile field resistance, in the wiring or even in the generator fields themselves. It not infrequently happens that a generator fails to work in one direction, but works properly when the car is moving in the other direction.

* * *

Questions for June

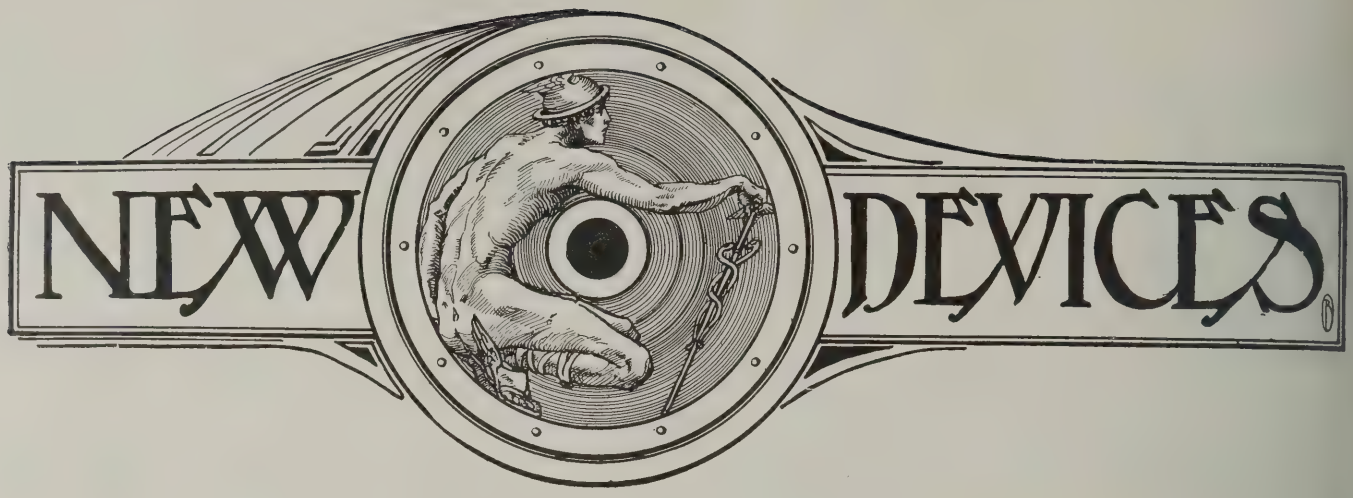
1. *Is there any explanation for the magnetic storm and the Aurora Borealis which upset so many communication lines on May 16th?*

2. *If you have two field bars of exactly the same size and appearance and only one of them is magnetized, how is it possible to determine which is the magnetized bar, keeping in mind that nothing but the two bars are to be used for testing?*

3. *When the battery on a car shows abnormally low voltage, is it better to test for dead cells before or after it has been charged?* *A. G. R.*

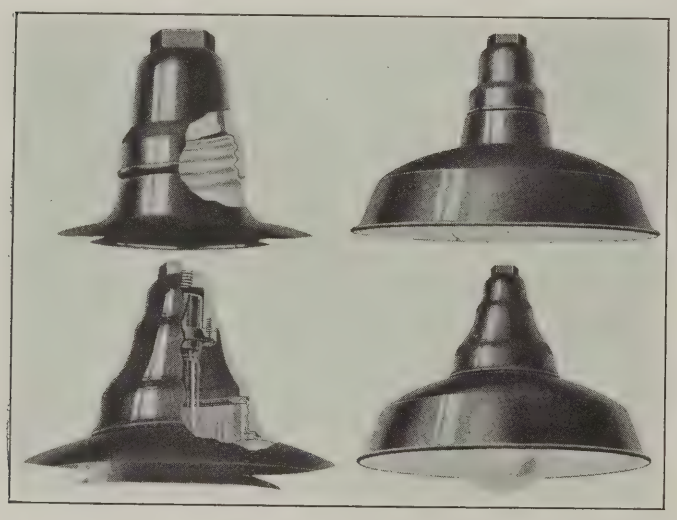
* * *

4. *Can you give me any information regarding the reconnecting of a 220 volt, 2 phase, 4 wire, 60 cycle induction motor so that I may use it on 440 volts of the same frequency?* *F. L. T.*



Lighting Fixtures for Heavy Duty Service

The heavy duty lighting fixtures, shown in the photograph, have been developed by the Benjamin Electric Manufacturing Company of Chicago. The upper two illustrations show a sectional view of the construction of one of these units and the general appearance of the unit when equipped with the R. L. M. dome reflector respectively. As may be seen from the illustration in the upper left-hand corner, the fixture is constructed in two parts, the reflector screwing into the supporting hood. These units are of rugged construction and are particularly suitable for use in railroad shops, yards, roundhouses and similar locations. The threaded connection makes it possible to remove the reflector from the hood for cleaning. This arrangement also has the advantage that in the event it becomes expedient to install reflectors of a different type at a later date, the assembly can be readily made without in any way disturbing the original hood or wiring.



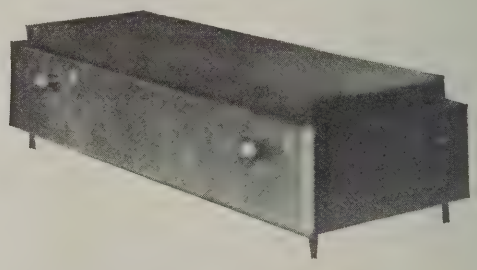
Heavy Duty and Gas Tight Fixtures

The lamp socket which is installed in these hoods is of such design as to lock the lamp in place when once inserted. Any attempt to remove the lamp without a proper key causes the locking attachment to instantly make a firm grip on the lamp base. The key which operates the lamp lock is inserted from below instead of from the side, and thus the weatherproof qualities of the fixture are not impaired as there is no opening required in the side of the hood.

The lower two illustrations show the heavy duty gas and vapor proof units of this line. The illustration on the left shows a sectional view of the unit and the construction may be readily seen in this photograph. Rubber gaskets are used as seals against gases and vapor, both in the upper part of the fixture, where the conduit entrance is located, and also in the lower portion where the vapor proof globe forms a gas tight joint. The reflector screws into the hood in the same manner as was previously described in the heavy duty lamp. The gas proof globe is so designed as to screw inside the reflector and when in place seals the entire interior of the lamp space most effectively.

Oil Stone Holder

A self-cleaning oil stone holder has been placed on the market by J. A. Raught, Racine, Wis. As shown in the illustration, the device has steel pegs to prevent its sliding on the bench and knurled head screws to tighten the oil stone in the holder. The stone is supported in the box by four pillars to hold it up out of the sediment. About



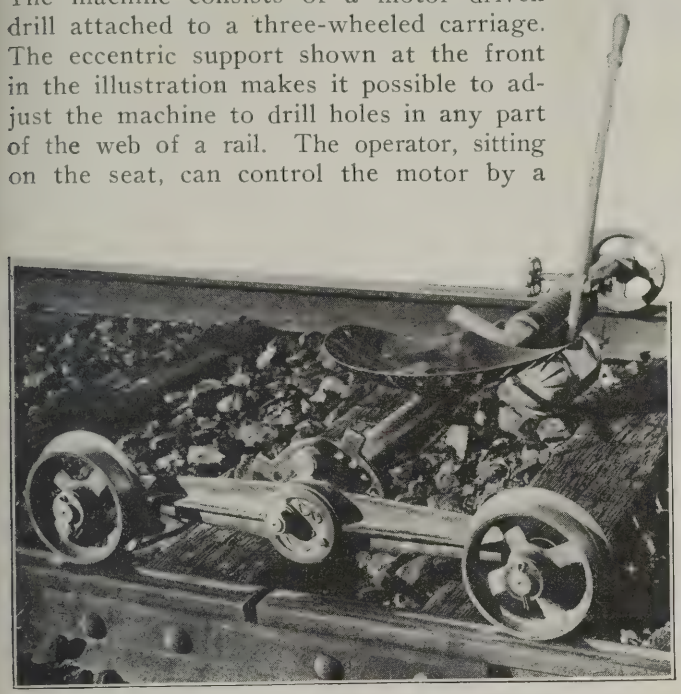
Holder With Oil Stone in Place

⅜ in. of oil is maintained in the holder, so that one side may be cleaned while the other is in use.

By turning the oil stone over occasionally the operator always has a clean, sharp cutting surface. The holder is made of cast aluminum ground and buffed, also cast iron japanned or nickel plated. Boxes are furnished with or without covers as desired. Various sizes are furnished to fit standard sizes of oil stones.

Portable Electric Track Drilling Machine

An electric track drilling machine has been placed on the market by Black & Decker Manufacturing Company, Baltimore, Md., which may be used for drilling holes in rails for track bolts or rail bonding. The machine consists of a motor driven drill attached to a three-wheeled carriage. The eccentric support shown at the front in the illustration makes it possible to adjust the machine to drill holes in any part of the web of a rail. The operator, sitting on the seat, can control the motor by a trigger switch in his left hand and apply pressure to the drill feed lever with his right hand. One man can easily remove the complete apparatus from the track. As yet it has not been considered desirable to develop these machines for voltages such as used on electric railways, and the motors are furnished wound for 32, 110 or 220 volts. Power is supplied by a portable farm lighting outfit or storage battery for the 32 volt machine, and is obtained from some convenient electric light circuit for the 110 or 220 volt machines.



Machine in Position for Drilling Holes for Track Bolts

New Tape for Armature and Field Coils

A new dry insulating material, manufactured by the Res-Pro Insulating Co., Inc., known as "Voltape," is attracting attention in the electrical field because of its unique construction, the variety of its uses, and its many advantages. Most of the tapes now used for binding armature coils have very slight insulating qualities until they have been dipped or treated with an insulating varnish.

Voltape is manufactured from an unwoven cotton base. Special carded cotton is impregnated with a Res-Pro insulating compound, and by a patented process, a tough and durable fabric is produced which, without any special treatment, has in a thickness of .007 in. a dielectric strength from 1200 to 1500 volts. It is furnished in all widths from ⅜ in. up.

Some of the special advantages of this tape, in addition to its high dielectric strength, are that it will absorb about the same amount of varnish as cotton tape, it has no selvedge edge, and a coil taped with voltape may be hammered into an armature slot without injury. This material has a slight stretch which enables it to form tightly around corners in a compact manner.

Louis O. Duclos, Boston, Mass., is the exclusive selling agent for the company.

Butt-Welding Machine for Drills

A machine for flash welding of high-speed steel, which will handle stock from ¼ to ¾ in. in diameter, has been developed by the Winfield Electric Welding Machine Company, Warren, Ohio. The machine has a self-contained, 6-step regulator and a 15-kw. transformer. A switch is located on the hand lever which is operated semi-automatically. The switch is set by a thumb latch on the lever and is tripped automatically after the weld is made. The lower dies are copper and the upper dies tool steel. All of the copper terminals are water cooled and it is not necessary to break the water connections when the dies are changed.

The work is clamped by hand in dies located at the front of the machine and a single toggle hand lever is used for upsetting the weld. The left-hand slide is adjustable to permit alining of the work and to regulate the amount of take-up in the weld. Adjustable stops are provided for backing up the work.

Type B6 Butt-Welding Machine for ¼-In. to ¾-In. Drills

The machine is said to be so constructed that the small particles formed by the flash cannot get into the movable parts and bearings. The upsetting slides are faced with hardened steel plates. All movable bearings have hardened steel bushings and pins, and are protected by felt wherever possible. The dies are set at the front of the machine so that the flash is away from bearings and slides. The clamping levers are placed back of the dies and clear of the flash, and clamp the work by means of hardened steel cams.

One set of four welding dies are provided. The machine occupies a floor space 42 in. by 40 in., is 56 in. high overall and the dies are 36½ in. above the floor. The machine complete weighs about 1,000 lb.

General News Section

The shops of the New York Central R. R. at Elkhart, Ind., will be reopened July 5, it is reported, on a piece-work basis.

Delaware, Lackawanna & Western.—According to a report of President W. H. Truesdale, work will start soon on the electrification of the Delaware, Lackawanna & Western R. R.

According to the Guaranty Trust Company an electric railway line from Siangtan to Changsha, China, a distance of 30 miles, is under consideration. Plans include the possible purchase of fifteen cars.

The Chicago, Milwaukee & St. Paul is converting a number of sleeping and parlor cars into open top observation cars to be used on the company's electrically operated lines in the Rocky and Cascade Mountains.

At Island Pond, Vermont, on May 13, the entire crew of a freight train of the Grand Trunk was arrested, together with another man, on charges of smuggling liquor into the United States from Canada. Customs officers are said to have surprised the gang, in a secluded spot, unloading liquor from the train into automobiles.

Economy Fuse & Manufacturing Company of Chicago, manufacturers of renewable type cartridge and plug fuses, is announcing a sweeping reduction in prices of Economy renewable fuses and "drop out" renewal links. The cut in price is made possible chiefly by the increased manufacturing facilities of the new plant on Greenview avenue at Diversey Parkway.

The American Electric Railway Association will hold its annual convention at Atlantic City, N. J., in the week beginning Monday, October 3, in the spacious and beautiful building which has just been completed on the boardwalk at North Carolina avenue immediately in front of Haddon Hall. The exhibits this year will be omitted.

The Association of Railway Electrical Engineers will hold its annual convention at the Hotel La Salle, Chicago, Ill., from Tuesday, October 18, to Friday, October 21. The board of directors, because of financial stress and serious business conditions, has determined that it is necessary to cancel the semi-annual meeting which is usually held at Atlantic City in June.

The Electric Service Supplies Company, Philadelphia, will act as exclusive selling agent for the Peerless Equipment Company of Hanover, Pa., manufacturers of Peerless Armature Repair Machinery and Segur Coil Winding Tools. Heretofore Peerless Armature Tools were manufactured by the Manley Manufacturing Company, York, Pa., and Segur Coil Winding Tools were manufactured by the Electrical Manufacturers Equipment Company, Chicago.

Wireless Progress in Finland.—Finland, which has hitherto had only a small 3-kw. wireless station with a range which would not carry messages much beyond Copenhagen, has just installed two new stations at Helsingfors, a 25-kw. Daniel-Poulsen system and a 35-kw. Marconi system, which will enable communication to take place with the whole of central Europe.

Wireless Between Italy and United States.—According to an announcement made recently at Rome by the Marquis di Solari, work will soon be begun on a powerful wireless station near Pisa for regular communication with the United States. Operation of the plant in 1922 is hoped for, the Marquis said in an address before the Italo-American Association.

The portrait of the owner will be required on commutation tickets of the Long Island Railroad if the company carries out its conditional proposal announced last month in notices to passengers. These tickets are very frequently used wrongfully by persons who do not own them, and the company has appealed to all ticket holders to use their influence to stop this unlawful practice.

Large Rail and Electrical Projects at London. A scheme has been proposed for a circular railway round London at a distance of about twelve miles from the center. Plans are also in an advanced stage for a new "tube" railway for the metropolis, running from the city southwards to the Crystal Palace district. More extensive plans are under consideration by the Ministry of Transport for the electrification of main line railways.

Radio Service Between Chicago's High Schools.—Chicago's twenty-two high schools are, according to the Wireless Age, to be equipped with radio-telephone and radio-telegraph instruments. This school system, the first of its kind, will be installed at a cost of about $50,000 and will make it possible to transact virtually all inter-high-school business by radio. Stations have already been established at two of the schools, the telephones having a day range of about 100 miles for the transmission of intelligible speech and the telegraph instruments a day range of approximately 200 miles.

The Rome Wire Company, Rome, N. Y., has added weatherproof wire to its manufacturing schedule, and its new weatherproof wire mill is now completed and in operation. This plant is two stories in height, 125 ft. x 325 ft., with floor space of 81,250 sq. ft., bringing the company's total floor space to 15½ acres. The new product rounds out the company's line of copper rods, bare and tinned copper wire, stranded cables, rubber-covered wires, magnet wires and weatherproof wires. It is the intention to carry large stocks of rubber-covered and weatherproof wires in the Rome warehouses at all times.

Interesting facts concerning the radio megaphone developed and arranged by Prof. Alfred N. Goldsmith of the College of the City of New York are printed in the *Wireless Age,* which says this instrument is the result of fourteen years of diligent research in the college's department of electrical engineering, no claim to invention of the apparatus being made by Professor Goldsmith. The new amplifier, the *Wireless Age* says, is distinguished from others by its extreme sensitiveness, its reliability, the high power of its amplification, the evenness and clearness of its tones and its ability to receive from long distances. With it messages passing between Nauen, Germany, and New Brunswick, N. J., Stavanger, Norway, and Marion, Mass., Lyons, France, and Tuckerton, N. J., Carnarvon, Wales, and New Brunswick, N. J., are heard at the college station with great distinctness. A commercial advantage of the apparatus is that by its use the cumbersome head harness worn by wireless operators becomes unnecessary.

South African Railway Electrification

The Office of the High Commissioner for the Union of South Africa, Trafalgar Square, London, W. C. 2, England, has announced that the time limit for which all tenders regarding the electrification of the Capetown-Simonstown and Durban-Maritzburg Lines, has been extended to noon, July 5, 1921.

Electrification in Philippines

The Manila Railroad Company is planning the electrification of its lines, according to information made public by the Philippine Government Commercial Agency. The power is to be developed from the Agno river in Central Luzon and a thorough topographical survey of the power site is being made under the direction of the company.

New York Electrical Society Elects Officers

At the annual meeting of the New York Electrical Society, held on June 3, 1921, at 4 p. m., in the Engineering Societies building, 29 West 39th street, the following officers were elected for 1921-1922; president, C. G. Young; vice-presidents, F. B. Colt, Ernst Woltmann, O. A. Kenyon; secretary, George H. Guy; treasurer, T. F. Honahan.

Money Talks

The Narragansett Pier Railroad, an eight-mile line in Rhode Island, which has been threatened with insolvency because of the competition of an electric line and automobile trucks, and from other causes, is to be kept running by the aid of contributions from two towns on its line. The president of the road having explained the situation, and the dependence of the towns on the road for the movement of coarse freight being clearly realized, town meetings unanimously voted specific appropriations. The town of Narragansett appropriated $5,000 and South Kingstown $10,000. By agreement with the road each town appoints a citizen to sit with the board of directors of the company. It is understood that the company agrees to continue operation at least until March 28, 1922, and to declare no dividends prior to that date. The road has three locomotives, and its line connects with the New York, New Haven & Hartford at Kingstown (township of South Kingstown).

New Swiss Radio Station

In order to comply with the terms of the concession granted by the Swiss Federal Government to the Marconi Radio Station, Ltd., of Switzerland, the company must construct a high power radio station and have it in service near Muenchenbuchsee in the Canton of Berne before next September. According to the Swiss General Telegraph Bureau the contract calls for a station having a sending range of 2,000 miles. The duration of the concession to the Marconi company will be for 25 years. The requirements of the concession are that only Swiss shall be employed and that all equipment and material used in the construction and maintenance of the station shall be of Swiss manufacture. Furthermore, should conditions arise in the country at any time that make it desirable for the government to direct the operations of this station, the federal government reserves the right to confiscate the equipment.

Careful Automobile Drivers

The Baltimore & Ohio began its campaign to enlighten automobile drivers in November, 1919, and the four million notices distributed since then, through the co-operation of state officers, and others, are believed actually to have reduced carelessness at crossings. About 100,000 observations have been made, and the percentage of automobile drivers who do not observe safety rules at crossings is smaller than it was in 1919. In January of this year, with 8,000 observations, the failures were five per cent; in February, 17,000 observations, failures four per cent; and in March, 23,000 observations, failures six per cent. Two years ago these percentages were about 25, and in 1920, 16 per cent. Non-observance of safety rule is, wherever possible, called to the direct attention of the driver; and the campaign is to be kept up with full vigor.

Safety Engineers Meet

The subject at the monthly meeting of the American Society of Safety Engineers, which was held on the evening of May 27 in the Engineering Societies building, New York City, was "Electrical Hazards and Their Safeguards." The program consisted of three papers which covered various phases of electrical work. The first speaker, H. S. Balliet, assistant terminal manager, Grand Central Station, presented a paper dealing with terminal equipment of the New York Central Railroad entering New York City. Mr. Balliet, with the use of lantern slides, showed how many safety devices were used in the reconstruction of the New York terminal system, and described methods and apparatus which expedite the movement of traffic into the Grand Central Terminal and make for safe operation. He pointed out the need for screens and fences as a protection around such devices as transformers and bridges, and stated that all high tension poles would be stenciled to warn against danger of anyone climbing them. He advocated protection to workmen on

all electrical circuits of 220 volts or over and said that the "safety first" slogan is probably the greatest of safeguards.

C. O. Van Dannenberg and W. W. Samuels, electrical engineers for the J. G. White Engineering Corporation, discussed the subject of high tension electric generation and transmission. Among the more important points discussed under this subject were the proper location and operation of high tension sectionalizing switches. The subject of maintenance of transmission lines under operation was also discussed and numerous tools were described which permit linemen to make taps and replace defective insulators with perfect safety on live lines. Various means of grounding high tension circuits were taken up and the safety features of each pointed out.

The safety which surrounds the operation of shop motors was briefly and clearly described by L. E. Smith, electrical engineer for the General Electric Company, whose subject was "Small Motor Problems and Industrial Control Equipment." Mr. Smith described the various types of safety switches used in connection with industrial motor equipment and explained in some detail the advantages gained from the use of these modern appliances.

Personals

Reinier Beeuwkes, electrical engineer of the Chicago, Milwaukee & St. Paul, has been granted a leave of absence for several months and has gone to South America with his family.

Frank Julian Sprague, who is frequently spoken of as the "father of electric traction," was awarded the Franklin medal by the Franklin Institute on May 19. In addition to his pioneer work with the electric motor, Mr. Sprague has had a hand in a large part of the electric railway development which has occurred in this country. He was graduated from the United States Naval Academy in 1878 at the age of 21. After five years of service with the Navy he resigned to join the technical staff of Thomas A. Edison, and in this capacity his duties related principally to lighting matters, to which he made several important contributions. His main interest, however, was early centered in the application of electricity to power purposes, both industrial and for traction, and in less than a year after he had joined the forces of Mr. Edison, he organized a company of his own for the further development of motor application. His enthusiasm and energy enabled him to overcome many heartbreaking obstacles and his work developed logically along the lines, first of the application of new types of the electric motor to general industry, and then successively to the trolley, rapid transit and steam railway electrification. Mr. Sprague also developed an electrical system of elevator drive and control, the problems of which were similar to those of traction. At the present time he is interested in a system of speed control and automatic brake application on steam trains.

F. J. Sprague

During his busy career, Mr. Sprague has been honored in many fields. At the Paris Exposition in 1889 he was awarded a gold medal. Again in 1904, at the Louisiana Purchase Exposition, he was awarded the grand prize, and also in 1910, from the American Institute of Electrical Engineers, of which he is a past president, Mr. Sprague received the Edison medal "for meritorious achievement in electrical science, engineering and art, as exemplified in his contribution thereto." He is also a past president of the American Institute of Consulting Engineers, the New York Electrical Society and the Inventors' Guild, and during the war was a member of the Naval Consulting Board. He has also acted as a consultant on some of the most important electrification projects.

The Franklin medal, which is one of the highest world awards, is the second medal awarded to Mr. Sprague by the Franklin Institute, the former being the Elliott Cresson medal, which he received in 1904 for his development of the multiple-unit system of railway control. The Cresson medal is awarded annually "to those workers in physical science or technology, without regard to country, whose efforts have done most to advance a knowledge of physical science or its application." It was given to Mr. Sprague in recognition of his many important inventions in the electrical field, the more notable of which are his contributions to the development of the electric motor, its application to industrial purposes and to the art of electric traction.

F. H. Wilkins, European general manager of the International Western Electric Company with headquarters in London, has been elected a vice-president of his company. Mr. Wilkins entered the employ of the Western Electric Company forty years ago, eventually becoming manager of its New York branch. In 1910 he went to Europe to look over foreign trade conditions and a year later was made European general manager of his company.

Trade Publications

The Condit Electrical Manufacturing Company, South Boston 27, Mass., has placed on the market its type D-17 oil circuit breaker with resiliently suspended tanks in single units up to 1,200 amp. at 15,000 volts and up to 800 amp. at 25,000 volts.

The Ohio Brass Company, Mansfield, Ohio, has issued a new catalog, No. 18. The catalog is in the form of a clothbound volume, 6 in. by 9 in., and contains illustrated descriptions of all of the products of this company: porcelain insulators, pole hardware, trolley materials, catenary materials, bonds and tools, third-rail insulators and car equipment.

Electrical plant accessories for 110-volt circuits, such as battery charging, rheostats, circuit breakers, resistor units and rheostats, are described in Circular 504, issued by the Ward Leonard Electric Company, Mt. Vernon, N. Y.

Railway Electrical Engineer

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Electric Power for Traction

The relation of railroad electrification to power supply is now causing much discussion. As much equipment as practicable should, of course, be standardized and it is contended by the advocates of direct current for railroad operation that 60-cycle alternating current, the use of which is increasing rapidly, will some day be universally adopted for power development in this country and that we must look forward to the time when all power for electric traction must be derived from 60-cycle, three-phase alternating current feeders. The advocates of alternating current power for traction purposes are naturally opposed to this contention, for 60-cycle power supply involves the use of rotating machinery in the substations of railroads using alternating current on the trolley. Alternating current motors for 60-cycle power are not as suitable for railroad traction as those designed for lower frequencies and if the power for traction is developed as single-phase power at some lower frequency, such as 15 or 25 cycles, the substations become simple transformer stations. Rotating machinery, or perhaps some form of arc rectifier, is always necessary in substations supplying power to a direct current trolley. Either kind of power for traction may prove to be generally superior to the other but that is still a mooted question.

It is pointed out by F. H. Shepard, director of heavy traction, Westinghouse Electric & Manufacturing Co., in an article in this issue, that it is not desirable to superimpose a variable railroad load on a lighting supply circuit which requires close regulation. To this it might be added that recent experiments indicate that for very high voltage, long distance transmission, it may be found necessary, due to physical difficulties, to develop power at some frequency less than 60 cycles. Advocates of alternating current power for traction lay great stress on the point that sufficient power for heavy and concentrated traffic movements can be supplied only by alternating current. This may prove to be true, but up to the present time direct current power has been able to meet all such demands of load that have been imposed upon it. In other words there are still too many variables involved to warrant curtailing the development of either kind of power for traction. It is highly probable that both kinds will be adopted as they have been in the past, except that the choice will be based more in the future on conditions of traffic and profile instead of being governed by laws and other extraneous influences which had much to do with the selection of equipment for the earlier installations. Railroad operating requirements should be of primary importance and special features of equipment should be subordinated to them.

The Demand of the Future

It is becoming more and more the practice to suspend car lighting generators from the body of the car rather than from the truck. There are many advocates of both methods of suspension and it is still a much discussed question as to which is the better system. Truck mounted machines have the advantage of shorter belt and the inherent property of keeping both axle and generator pulleys in line when going around curves. On the other hand, the body hung machine is higher above the roadbed and is consequently further removed from the injurious contact of dirt, gravel, snow and ice. The body suspended machine requires a longer belt, however, and the axle and generator pulleys are not in line on curves.

It does not require much consideration to conclude that neither the truck mounted machine nor the body hung outfit is the ideal solution of the generator question. The one big outstanding factor in the cost of car lighting maintenance is the belt. Not only is the belt operation liable to be faulty in bad weather, but the loss of belts runs into very appreciable amounts. Car lighting equipment has been brought to a remarkable degree of perfection and it would seem that there was little left to be desired in the way of service that could not be accomplished. What development lies in the future must be by way of economies effected and in this direction no factor is deserving of more attention than the elimination of the belt drive.

The idea of generators being directly driven from car axles by means of various mechanical devices other than belt is not new. Experiments have been tried on a small scale and have demonstrated that the belt can be eliminated. It is true that the substitution of some sort of direct drive in place of the belt would involve a large initial expense, but it is also true that such expense might be more than offset by the saving in belt maintenance, both for material and labor. It requires courage to make radical changes in established practices with the hope of ultimately gaining in economy of operation. Nevertheless it is reasonably certain that the belt drive will not always be tolerated. Progress in any art demands improvement and betterment and the time has come when car lighting men should give earnest consideration to the shortcomings of the belt drive, and be courageous enough to make a real

effort to substitute a more enduring and more efficient means of transmitting power from the car axle to the generator.

Properly Lighted Buildings

The correct lighting of railroad buildings is a subject upon which too much cannot be said, for there are many such buildings in which the lighting is totally inadequate. To be sure, there are notable examples of first-class lighting on some roads and these serve very largely to emphasize the lack of proper illumination on the others. The truth of the matter is that it is not commonly known what really constitutes good lighting, nor by what type of unit it may be secured. Those who are responsible for railroad lighting frequently realize that an abundance of artificial light is a requisite and try to meet the need by installing larger units and more of them. This might almost seem to be sufficient, but it does not always prove to be the case. It is quite possible to install lighting units capable of giving more light than is needed and yet be wholly unsuited to meet satisfactorily the requirements. Usually the installation of lighting units calls for a careful study of all the conditions which obtain in the building to be lighted, and it is only after such a consideration that a thoroughly successful lighting system can be laid out. In this issue of the *Railway Electrical Engineer*, J. H. Kurlander, of the Edison Lamp Works at Harrison, N. J., presents an article on the electric lighting of railway buildings, in which the requirements are pointed out together with the means used to meet them. Photographs of some excellently lighted shops show conclusively what can be accomplished when the proper thought is focused upon the subject. As railroad buildings on different roads are quite similar in design, valuable suggestions may be obtained from this article.

Carbon Arc Welding

Although there is no scarcity of welding operations performed by the metallic arc process, the older method using the carbon arc has been largely relegated to the background. It will be recalled that carbon arc welding was used as early as 1881, although we are inclined to look upon the advent of arc welding as a much more modern development. The truth is that such developments as have been made in the welding art in the past few years have been largely in connection with the metallic arc. Real progress has been made and to such an extent that metallic arc welding is assured a permanent place in the industrial world.

On the other hand, it should not be forgotten that there are jobs which can be done more economically and advantageously by the use of the carbon arc. This applies principally to greater speed in building up work and to lower costs on heavy work. The fact that the work is performed by a carbon arc has given rise to a belief that the metal applied carried carbon into the weld. This belief does not appear to be sustained, however, as the welded parts are easily machined which would not be the case if any excessive amount of carbon were present. Moreover, the carbon arc can be used in welding copper with complete success.

It will be seen, therefore, that not all of the advantages lie with the metallic arc process, and in general it may be said that each kind of welding has its own field for which it is best suited. It does not always pay to be such a devotee to one particular method as to overlook real economy that may be readily enjoyed by digressing from the beaten path.

Toning Up the Organization

In spite of the fact that the Transportation Act of 1920 calls for the consolidation of the railroads of this country into a limited number of large systems there are reasons to question the wisdom of this action. A survey of the field indicates that some of our best operated and strongest roads are less than one thousand miles in length. There may be many reasons for this, but one thing is certain that the chief executive is better able to project his personality down to the ranks than in the case of the larger systems. The railroads of this country have developed rapidly in recent years and ofttimes the chief executive is entirely too far removed from the subordinate officers to get the best results.

The railroads in this respect are not very different from the large industries. The latter, however, in many instances have taken steps to offset the difficulty by making a bigger man of the foreman and giving him a better insight into the policies of the institution. After all it is the foreman who represents the company in dealing with the men. If the foreman and subordinate officers are not carefully trained and advised as to the policies of the company and the reasons for doing things a certain way they can hardly represent the company to advantage. This has been the cause of countless misunderstandings with the men, resulting, in many cases, in loss in the morale and lowered standards of workmanship. Now that the railroads are going through a period of reorganization and are getting ready for the larger tasks which lie before them it is important that steps be taken to strengthen the hands of the foreman and to give more consideration to the selection and recruiting of the forces, and the training of the men and their promotion.

The foremen must be selected, developed and educated on a different basis from practices which have been followed in the past.

New Books

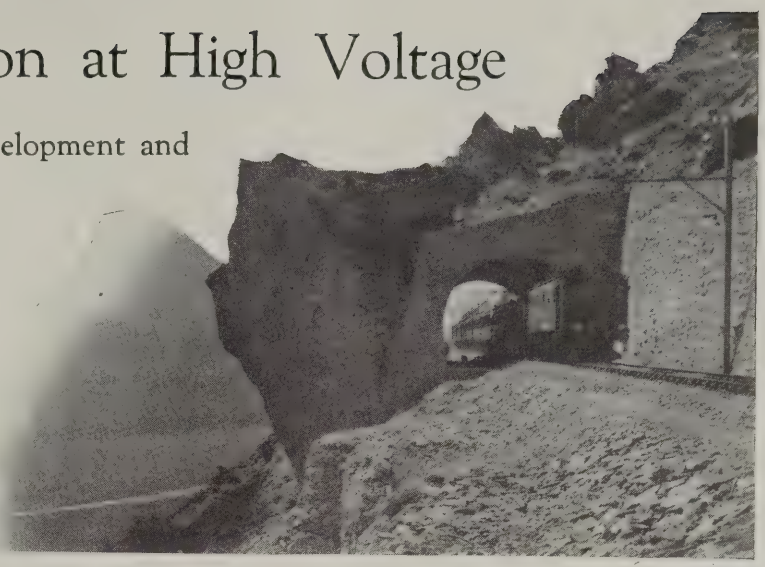
The Electrification of Railways. By H. F. Trewman. Published by Sir Isaac Pitman & Sons, Ltd., London and New York, 1920. (Pitman's technical primer series.) 78 pages, 4x9 in. Bound in cloth.

This little volume is an outcome of the discussion as to the advisability or otherwise of electrifying the railroads of Great Britain, a subject of general interest because of the necessity for relieving railway congestion and utilizing coal in the most economical manner. Without going into technical details covered in the books on electric traction, the author brings forward the commercial aspect of the matter and calls attention to some of the main questions to which attention must be paid. Sufficient electrical information is given to enable these points to be understood by readers who are not electricians, as well as those who are familiar with electrification problems.

Railroad Electrification at High Voltage

Alternating Current Equipment—Its Development and Relation to Power Supply

By F. H. Shepard
Director of Heavy Traction
Westinghouse Electric & Manufacturing Company



Train on Loetschberg Railway, Switzerland, Hauled by 15,000 Volt, 2,500 hp. Locomotive

THE overhead trolley is now accepted as the standard contact system for American railroad electrification, and, in fact, is the only contact system suitable for high voltage. The expansion of the use of electric power has been essentially due to the use of high, and still higher voltages. How, therefore, can we hope for electrification in its highest estate without recourse to high, and still higher voltage on the trolley?

The first use of electric power for full size railway trains was on the Baltimore & Ohio tunnel in 1895. The commitment for this had been made as early as 1891, when the Baltimore tunnel was under construction. This

First Experimental Single-Phase Car, Pittsburgh, Pa., 1892

operation was heralded as "Railway Electrification," and the success of these locomotives led to popular references to the "death knell of the steam locomotive." Subsequent history has shown how far afield these popular references were.

The various studies and consideration for extensive electrification always led to the economical necessity that the contact system be operated at some high voltage. A number of studies were made in which three-phase working conductors were considered. One of the most important of these was that for the Cumberland grade of the Baltimore & Ohio by Messrs. Duncan and Hutchinson, in 1896. The first extensive application of this three-phase power was on the Valtellina Railroad in Italy in 1901.

Alternating Current Tried in 1892

As long ago as 1892, Benjamin G. Lamme had experimented with a commutator type motor, using alternating current at very low frequency. While this experiment was successful from the standpoint of motor design, the development of the alternating current system lay dormant for a number of years, owing to the great pressure of other development. Mr. Lamme, about 1900, in order to respond to the increasing demand for a high voltage trolley, resumed his consideration of this development, and, in 1901, a contract was taken for an interurban installation for the railway line which was projected between Washington and Baltimore. The first public announcement of this was made in Mr. Lamme's paper before the American Institute of Electrical Engineers in September, 1902, and was received with great enthusiasm throughout the technical world. The equipment was built, but never installed, owing to the financial difficulties which prevented the completion of the construction of the railroad. This equipment comprised four 100 h.p. motors at 16 2/3 cycles, with 1,100 volts on the trolley, the motor voltage of 220 being derived from a trans-

First Experimental Single-Phase Locomotive for Heavy Haulage, East Pittsburgh, Pa., 1905

former carried on the car. This equipment was run on a test line at East Pittsburgh, and operated with entire success.

The endorsement this practical undertaking gave to the single-phase system led to immediate activity by other manufacturers throughout the world. This comprised that of the General Electric Company, with a repulsion type of motor, described in the paper of W. I. Slichter,

before the A. I. E. E. in 1904; the Winter-Eichberg armature excited repulsion motor; the Siemens' series motor and the series motor of the Oerlikon Company, as well as numerous alternatives, such as the Finzi, Deri, Latour and others. The enthusiasm with which the alternating current motor was embraced has unfortunately proved to be a serious handicap to its actual development and use. This is due to the fact that many of the early applications were made with equipment of insufficient capacity, undeveloped design, or untried features of that period, which had no place in regular operation. The voltage of the trolley increased to 3,300, 6,600, 11,000 and even to 16,000 volts; the frequency was 15, 16 2/3, 25 and 42 cycles.

Results of Early Application

Most of these installations were designed to accomplish service comparable to that performed on the interurban railways, and as it was possible to maintain schedules far in excess of the capacity of the motors by voltage control of the single-phase equipment, the motors were almost always outrageously overloaded. This has been the principal reason that the maintenance costs were excessive.

At this time, with direct current, the practical limit of voltage supply was that for the motor—then, 550 volts. To raise the supply voltage, alternating current was adopted as the only available means.

The handicap imposed by the combined operation over direct current lines ultimately led to the replacement of some of this equipment with direct current at 600 and 1,200 volts.

The legislation compelling the use of vaporless traction in the Fourth Avenue tunnel leading to the Grand Central Terminal at New York, compelled the adoption of electric service for that operation. While the New York Central adopted the third-rail system, the New York, New Haven & Hartford, which was under legislative restriction prohibiting the use of the third rail in the state of Connecticut, decided to use an alternating current system with 11,000 volts on the trolley as that which promised to be the most suitable for its requirements, with special reference to the needs for the future.

The Westinghouse Company had, in the meantime, through its study of the electric service for the St. Clair tunnel, developed a 120-ton locomotive, which had been operated experimentally at East Pittsburgh with satisfactory results. This experiment settled the questions of the effect of pulsating torque upon adhesion, commutation of large motors, and the various questions of control. The use of the overhead trolley on the New Haven led to a controversy, which oftentimes took the nature of the burlesque, regarding the relative virtues of direct-current third-rail versus the alternating-current trolley.

The New Haven undertaking was a courageous one, comprising in its initial installation thirty-five 1,000 h.p. passenger locomotives, capable of operating at speeds up to 80 miles an hour. These were originally laid out as the geared type, but owing to the preference for the gearless the locomotives as constructed were of that type, with the resulting increase in weight entailed. The design of this locomotive was further involved, due to the undertaking to operate over the direct current third rail into the Grand Central terminal. This installation, in many respects, was truly a pioneer one, involving the determination of many features which had previously been untried. Among them were the following:

1. The generation of single-phase power in large steam turbo units.
2. The installation of high voltage trolley exposed to the continued exhaust from steam locomotives.
3. The installation of an overhead conducting system on a four-track railroad.
4. The development of a selective system of circuit breaker protection to handle short circuits of high capacity and great frequency compared to the commercial service then accomplished.
5. The first use of gearless single-phase motors.
6. The combined use of alternating current and direct current on locomotives.
7. The inauguration of a service without the trial period of elements included in power house, line and locomotive.
8. The extensive undertaking of electric service by a steam railroad organization.

The result of the New Haven installation was to establish the sufficiency of an overhead trolley at high voltage

Electric Passenger Train on the New York, New Haven & Hartford

for railroad service. There was demonstrated as well, the flexibility of alternating current in railway service. This service developed, on a considerable scale, the various conditions which are necessary to satisfy the successful operation of an alternating-current system. In the case of the generating plant, it was shown that damper construction was necessary on generators and that circuit breakers of greater capacity and more rugged type were required. For the line, there was shown the type of installation necessary to withstand the exhaust of the steam locomotives, and also that the initial requirement for mechanical strength in the overhead conducting system was far less than anticipated, and, furthermore, that great attention should be given the question of flexibility at the traveling point of contact. On the locomotives there was developed the need for greater ruggedness in switches, auxiliary parts and connections, as well as certain changes in the mechanical parts of high-speed electric locomotives. The greatest handicap to the most successful operation and one which still prevails, is that due to overloading the equipment. This has apparently been difficult, if not impossible, to prevent, and prevails even to this day to an unfortunate extent. The education of the operating forces on steam railroads has, however, been progressing, and it will undoubtedly follow that railroad electrification in the future will recognize the inevitable fact that electrical apparatus of no kind or type can be overloaded without undue cost for maintenance.

Owing to the accepted advantage of a high voltage trolley, and due to the activities of Frank J. Sprague, complemented by those of James Bryan, the equipments for 1200-volt direct current operation for the Pittsburgh, Harmony & New Castle Railway were built in 1906 and

placed in operation in 1907. These equipments were built by the General Electric Company of America. Previous to this time, there had already been placed in operation, in Europe, equipments at 850 and 1,000 volts direct current. The voltage of 1,500 volts was developed later by the Westinghouse Company for the Piedmont & Northern and the Southern Pacific Company. The overhead trolley at 2,400 volts was used on the Butte, Anaconda & Pacific with 80-ton locomotives, and in 1916, the Chicago, Milwaukee & St. Paul inaugurated its notable installation of 440 miles across the Rocky mountains at 3,000 volts direct current.

The Use of High Voltage Alternating Current for Traction in Europe

In Europe, following the initial development of 1904, there has been carried on a comprehensive analysis of high voltage railway electrification with the use of alternating current and also with direct current. In Sweden, comparisons were made with direct current voltage as high as 4,000 volts on the trolley. Decision has followed in the case of Sweden, Norway, Germany, Austria and Switzerland to standardize upon 15,000 volts, single-phase, at 15 and 16 2/3 cycles, and there are now in operation approximately as follows:

In Sweden, 300 miles of track, with 125 miles under construction; in Norway, 60 miles, with 50 miles under construction; in Germany, 600 miles, with about 100 miles under construction; in Austria, 200 miles, and in Switzerland, 300 miles, with 300 miles under construction.

In Italy, following the successful operation of the Valtellina Railroad, there has been constructed about 600 miles using three-phase at 3,300 volts, and this has been settled as standard for all the heavy railroad operation in Italy, which includes practically the whole of northern Italy. For the lines of light traffic, consideration is being given in Italy to the use of 42 cycles and a higher voltage trolley, and also to a transmission system for both railroad and commercial use, with possibility of high voltage direct current on the trolley.

In France, subsequent to the decision of the Midi Railway to electrify with single-phase, there followed a controversy with the post and telegraph department of the government which has finally led to the decision to use 1,500 volts direct current with a third rail conductor as a standard for all the railways in France.

In England, 1,500 volts direct current with third rail has been adopted as the preferred type, the overhead construction being considered impracticable for general use on account of the limited overhead clearances, although in England the most extensive electrification, that of the London, Brighton & South Coast, will be continued with extensions of the single-phase trolley. In Belgium and Holland, the importance of multiple unit service with small distances and light trains has led to a decision to use 1,500 volts direct current; in Belgium, with third rail, and in Holland, with the overhead trolley.

Present Conditions in America

In America, the commission of the Pennsylvania Railroad, after nearly two years' investigation, decided to use the alternating current trolley at 11,000 volts and 25 cycles. There followed the electrification of the Philadelphia terminal at Broad Street, which includes suburban service as far as Chestnut Hill and Paoli. The Norfolk & Western decided to use the single-phase trolley, and, for extremely heavy service, has used the split-phase type of locomotives, the induction motors being fed from a single trolley through the medium of a phase converter.

It should be recognized that the most comprehensive electrification in America involving high speed passenger service, freight service, multiple unit service and switching service, is that of the New York, New Haven & Hartford, where some 500 miles of track are operating at 11,000 volts on the trolley. In this service there are more than 100 electric locomotives and a large number of multiple-unit cars used for the local passenger service as well as classification yards of great extent.

The heaviest service performed electrically is that on the Norfolk & Western, where coal traffic is moved with

A 15,000-Volt, Single-Prase Locomotive in Service in Lapland, Sweden, 1920

heavy tonnage trains over the Elkhorn grade section. The performance of each electric locomotive in this service is the practical equivalent of four of the large Mallet steam locomotives replaced. Current input as high as 15,000 kilowatts per train has been reached in this operation. The dispatch with which this service is handled is double that for the former steam service, and this installation forms a good illustration of the increased capacity which may be secured through electrification.

On the Pennsylvania Railroad, at Philadelphia, with multiple unit trains the flexibility of operation has very greatly reduced the congestion, which would otherwise have required a large addition to that terminal.

In general, an electric locomotive has been used to supplant a steam locomotive and, in this respect, has followed the general history of electrification of other industries. While this has been of benefit, the great value for electrification, and this applies especially to America, lies in the ability to accomplish, with electric power, service which would be entirely impossible with steam.

Future Needs

There is arising in America the imperative need of greater capacity for our transportation systems and greater dispatch in the movement of traffic. This latter, in fact, seems to be the logical way by which expansion of our railroad machine can take place. There is no good reason why an electric locomotive cannot remain at the head of a train for a run of hundreds of miles, or why electric locomotives cannot haul a train at speeds much in excess of those which are ordinarily attained with steam service.

There will develop, therefore, with the extension of electric power, the need for a large increase in motive power for each train unit. This may be taken to be roughly equivalent to four times the maximum horsepower now used for the propulsion of a train by steam. This will be utilized in hauling larger freight trains at higher speeds and will enable traffic movement to be handled on schedules which will be somewhat comparable to the movement of passenger trains. Thus, an electrically hauled freight train will be able to continue on the main line for the larger part of its course, thereby facilitating its arrival at terminal points on schedule, which alone will go a long way toward reducing the present serious congestion at terminal points. In fact, except for local distribution, the need for terminals should very largely disappear. A step in this direction was developed to clear up the congestion which existed on our railroads during the past year, trains, in many instances, being made up and run solid for great distances.

If this view is to be taken as to the utility of electric power in the movement of traffic, consideration will have to be given to the still larger concentration of electric power for single trains. The only practical way this can be accomplished is by a high trolley voltage, and this is most readily secured by the use of alternating current.

A great advance has been made in the design of direct current electrical apparatus, so that it is now possible on locomotives to build apparatus which functions successfully with 3,000 volts on the equipment. With direct current, however, the equipment, including the auxiliary apparatus, must necessarily be built to correspond to the voltage of the trolley, while with alternating current the equipment can be designed for the most economical and conservative voltage, and, through a static transformer, receive power from an alternating current trolley at a comparatively high voltage. This is shown by the use of motors of 300 to 400 volts from a 15,000-volt trolley. In fact, as far as the equipment is concerned, its design is quite independent of the trolley voltage.

Inasmuch as some time in the future it is universally accepted that the operation of our railroads with electric power will be great in extent, the development necessary to utilize electric power with the least restriction is that which should be given the utmost consideration. It should not be taken as fanciful to consider a district with complete electrification of the main lines of 500 to 1,000 miles handling the heaviest kind of traffic. The large

Passenger Train at South Portal of the St. Gothard Tunnel, Swiss Federal Railways, 1921. Locomotive Develops 2,250 h.p. from a 15,000-Volt, Single-Phase Trolley

trains, and the occasional bunching of trains, which is inevitable on certain sections of this major electrification, will cause a relatively poor load factor.

Since this is a condition which should be recognized, it is obvious that the best use of the investment for transmission and transforming apparatus local to any given section of railway will be that which utilizes the highest voltage for the supply of power to the trains. In other words, to meet the concentration of loads which will be necessary in the future the tendency is toward the highest practicable voltage on the trolley as a matter of economy.

Methods for Meeting Demands of the Future

There follows logically the suggestion that even with the highest voltage on the trolley the demand for railroad power should be equalized by the inclusion of many miles of railway deriving their power supply from a common feeder. This, in turn, could very well be at the highest practical voltage, so that it might be considered that hundreds of miles of railway would be fed from a super railway feeder.

The traffic movement on our railways varies during the day, from day to day, and from season to season. It is also subject to fluctuations due to conditions of weather and derangements in train service due to obstructions on the track, wrecks, and other causes. Allowance must be made for a considerable flexibility of movement to avoid congestion. Unfortunately, this condition does not produce an ideal demand from a power generating system,

so that a railroad load is not generally considered to be a desirable one.

Close regulation of voltage for railway use is of less importance than that for industrial use, especially where a lighting load is carried, so that an independent railway feeder should be more economical than supply from a common feeder system with its requisite regulation with a superimposed railway load.

For such a scheme of power supply to our railways, it should follow that power could be taken from the various regional generating systems for common supply according to a schedule or set condition, which could be adapted to use power in the most effective manner. For instance, during times of lesser demand for commercial power, such as nights, Sundays and holidays, there should be little, if any, restriction of power supply from any of the power systems. In the case of hydro plants, the demand should recognize the characteristics of each system, whether dependent upon stream flow or water storage. In the case of steam plants, consideration could be given to the effective loading of the steam generating units in operation. At times of maximum demand for commercial load, the roalroad demand from any system could be limited according to a definite schedule which would avoid super-imposing the peak loads for lighting and urban transit upon the railroad demand.

With such flexibility of relation to the various power systems, the amount of spare generating apparatus to provide for emergency would be lessened. In fact, a large part of the railroad load could, undoubtedly, be furnished by assigned generating units, and through their regulation, transfer of load would be readily secured over the super railway feeder, independent of the commercial demand and net work.

For such minor transfer of power between the railroad system and the commercial network as might be advantageous, motor generators could be used, thus lessening the burden of cost due to a frequency for railroad use which may differ from that of the commercial net work.

The expansion in electrical generating capacity for industrial and commercial use has been phenomenal in America. Undoubtedly, this growth is destined to continue to very large proportions. The generation of electric power for railroad use may also be expected to develop and grow. Each, therefore, should be able to develop without restriction by the other, and each in the utilization of nature's resources, could very properly be used to complement the other. It would appear, therefore, that we have not yet reached the time when railroad electrification should be dominated by conditions of power supply and distribution for other purposes.

Everlasting watchfulness is the price of safety. Think of the loved ones at home before taking a chance, says the National Safety Council.

No makeshift will settle the railroad question. It can be settled only upon the principles of sound business, which require that there be enough revenues to meet expenses and to pay a fair return upon the investment; and that competition be stimulated and individual initiative be encouraged. No scheme to make up the deficit will prove beneficial; the deficit must be eliminated. That is the crux of the problem which confronts the nation.—*Washington Post.*

New Suspension for Body Hung Generator

All of the dining cars on the New York, New Haven & Hartford, equipped with the 4 kw. truck mounted generators, manufactured by the Safety Car Heating & Lighting Company, are being fitted with a new type of body hung suspension. Two views of this suspension are shown in Fig. 1 and Fig. 2, while the parts used in its construction are shown in detail in Fig. 3. The upper part of the suspension consists of a U shaped piece of 5/8 in.

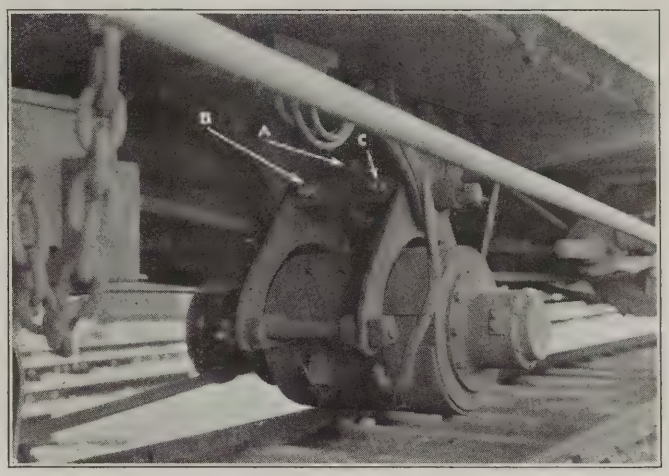


Fig. 1—New Type of Generator Suspension With Important Parts Indicated

boiler plate, bolted to the underside of the car. The lower part of the suspension which is secured to the generator is also made of 5/8 in. boiler plate and is suspended from the upper part of the suspension by a suspension pin made of 2 in. steel shafting 19¼ in. long. Bushings are used around this pin where it passes through the upper part of the suspension and the pin is free to turn in these

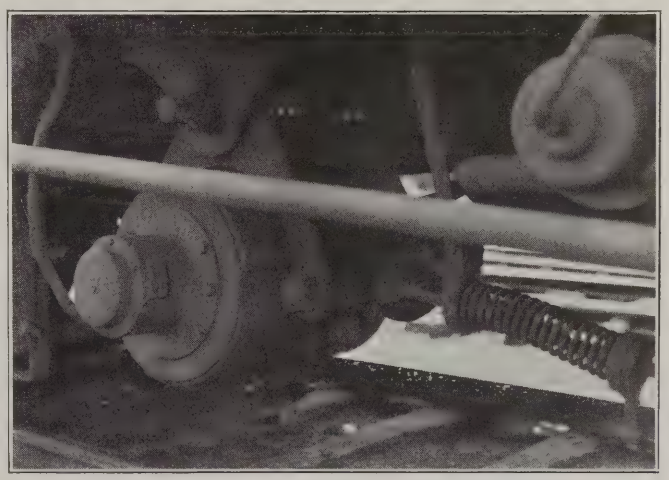


Fig. 2—Another View of the Same Equipment

bushings. The holes in the lower part of the suspension, through which the pin passes, are drilled out larger than the pin itself to allow for proper alignment of the generator.

A two-part split bearing 1½ in. long, marked *D* in Fig. 3, surrounds the center part of the suspension pin and is held in place by the U bolt *A*, Fig. 1. When it is desired to change the alignment of the generator, this U

bolt is loosened. This makes it possible to take up the cap screw *B*, Fig. 1, and release the cap screw *C*, or conversely, take up on *B* while *C* is released. Similar cap screws are provided on the opposite side which are shown in Fig. 2. After the generator has been put in proper alignment, the four cap screws, with their lock nuts, are tightened and the U bolt is once more pulled up tight.

The generator is secured to the lower part of the suspension on one side by a 1½ in. bolt, 18½ in. long. This is shown in Fig. 1. On the other side the generator is secured by two 1½ in. bolts, 7 in. and 8¼ in. long, respectively, shown in Fig. 2. The tension spring is attached to the longer one of these two bolts. The manner in which the tension spring is mounted is clearly shown in Figs. 2 and 3. Lubrication for the suspension pin is provided by short pieces of ⅛ in. pipe tapped into the upper sides of the two bushings. These pipes are capped to exclude dirt and are long enough to contain a reserve supply of oil. One of them is shown in Fig. 2.

Considerable difficulty was experienced in obtaining sufficient belt clearance on these cars, but all of the suspensions installed have been giving excellent satisfaction with good belt mileage. The suspension was designed by F. Zimkowski, general car lighting inspector. There are 34 now in service and parts for 25 more are in process of construction in the New Haven shops at Readville.

Another type of suspension was also designed by Mr. Zimkowski in which all of the original suspension was moved out under the car, and mounted on a special frame bolted to the center sill. This made it possible to place the axle pulley at the center of the axle, but due to the peculiar construction of the cars only a few of this type of suspension could be used.

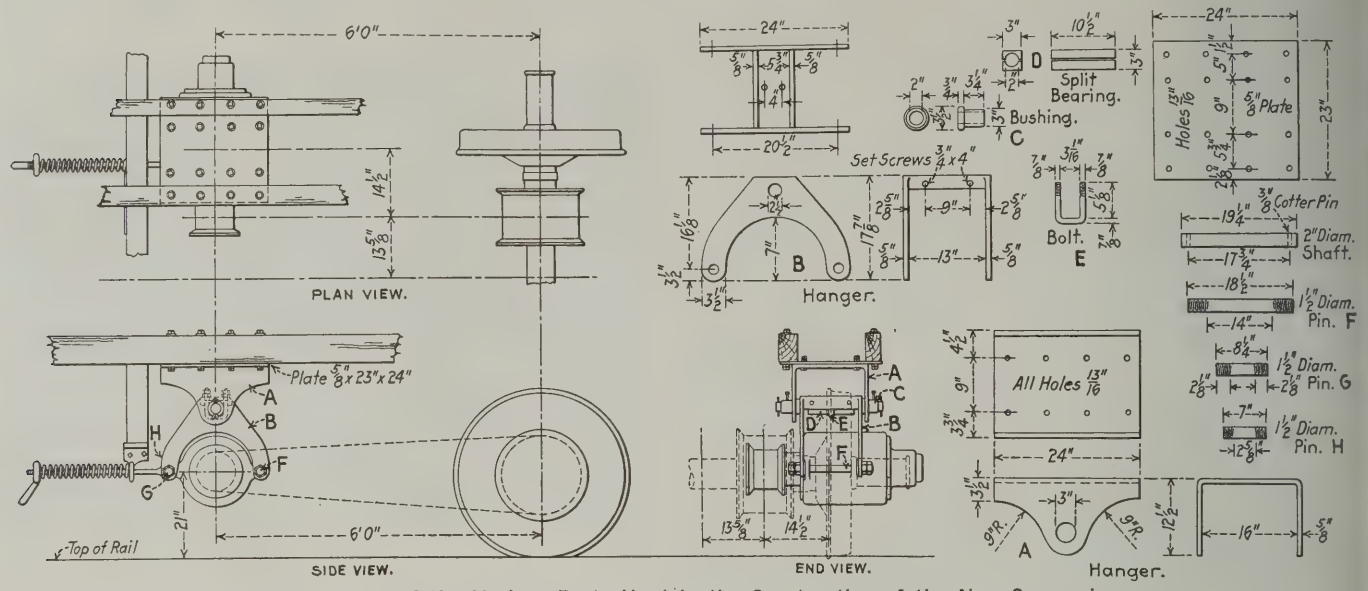


Fig. 3—Details of the Various Parts Used in the Construction of the New Suspension

At a joint session of the Directors' Executive Committee and the Meetings and Papers Committee of the American Welding Society on June 21 it was definitely arranged to hold the annual autumn meeting of the society in Philadelphia commencing October 17.

Photo by Keystone View Co.

A View of Salida, Colorado, Showing Railway Yards

An Electrically Welded Oil Tank.

The Electric Welding of Oil Storage Tanks*

Welded Construction Eliminates Loss from Leakage and It Is Estimated Tanks Will Outlast Riveted Containers

THE riveted oil storage tank is the present standard, and the details of construction are well known. In fabricating materials for the riveted tank, it is generally necessary to make templates, mark, punch and ream the plates. It is important that the edges of the plates are faired and that the size of the sheets is accurate. When erecting the tank it is necessary, in many instances, to drift as the plates must be drawn up tight for riveting. Neglect in any one of these things will produce an inferior article.

A number of joints are necessary in order to make the riveted construction possible, with angles, gusset plates, etc. The single, double, triple riveted and butt-strapped joints, as the load may require, increase the possibilities for leaks, which increase with the number of holes and caulked joints.

The bottom and first course of a riveted tank are constructed on horses and after test, this portion of the tank is lowered down into final position on the foundation. The strains in lowering this portion of the tank may cause leaks which cannot be discovered. Again leaks start when caulking edges have been strained unduly or often. Wind pressure, filling and emptying of the tanks, temperature changes causing breathing of the tanks and corrosion are some of the other causes of leaks.

The maintenance charges on a riveted tank start within one year of its construction.

The loss through leaks, seepage and evaporation from riveted tanks has not yet been closely estimated, but it is certain that the amount of the loss is tremendous, especially for the lighter grades of oil. One representative oil company roughly estimates its average yearly leakage loss at 5 per cent of the contents of storage tanks, with a higher percentage for the lighter grades and a smaller percentage for the heavier grade of oil. It is the opinion of some experts that this estimate is too low.

It is reasonable to assume from the above that the yearly loss through leakage on some types of oil will amount to 20 per cent of the value of the tank. Over a period of twenty years, this would amout to about 400 per cent of the value of the tank.

The oil industry has, with exceptional care and efficiency, developed the refining of the crude oil and put tremendous investments into appliances which will extract a small additional percentage of lighter grade products from the crude. On the other hand, a very large percentage of these products lost through the inherent deficiencies of the riveted construction of tank, in which they store these finished products. It has been determined that the deterioration of the tanks starts at the points where the skin of the plates is broken. As an example of the deterioration of riveted structures being mainly in the way of the riveted joints may be cited a 220 ft. smoke stack which showed considerable deterioration near the top. In drilling test holes and making a general examination of the smoke stack it was found that the deterioration confined itself practically to a belt following the outlines of the riveted joints. A number of the rivets could easily be knocked out with a hand hammer while the centers of the sheets were, without exception, practically as good as new. Therefore, it is to be assumed that tanks with the skin of the plates unbroken anywhere, will last longer.

Oil and grease are used for protection of tools and machinery against rust and the conclusion might be drawn that the oil would protect oil tanks from deterioration. However, the acids in some grades of oil attack the tanks and especially the rivet joints, and the tanks

*Abstract of a paper presented before the Metropolitan Section of the American Welding Society by William Schenstrom of the Electric Welding Company of America.

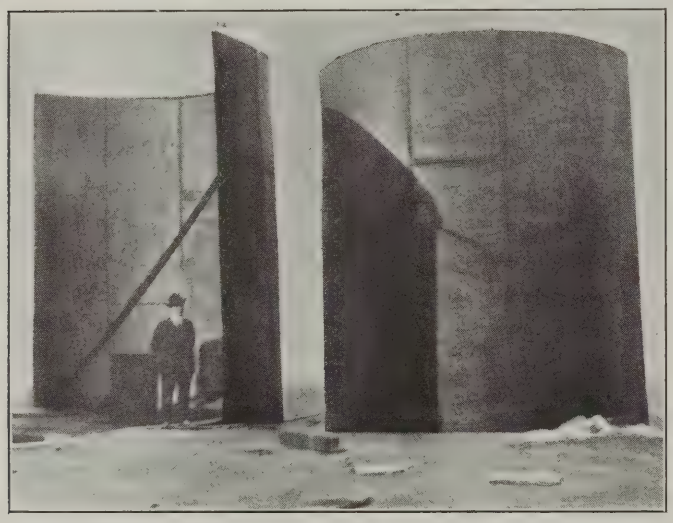
holding oils with a large proportion of acids, have been known to be useless after three years. The maximum life of a 55,000 barrel riveted tank, left in one position, is estimated at twenty years.

The general conclusion would be that the oil storage tank of the present standard and construction, while satisfactory for want of something better, has certain limitations, which makes an improved design and construction method desirable.

Electrically Welded Construction

The electric arc welding method has for a long time been considered as the logical one to produce a more satisfactory construction than is possible with the riveting method and recently considerable construction work of welded oil refinery equipment, including various sizes of oil storage tanks, has been successfully completed in the mid-continent, Southwest oil fields, as well as in the East.

In designing a welded tank for the present time it is proper to follow the fundamental outline, such as the lapping of plates, as in riveted construction. New methods of welded construction of tanks are now being developed, which will involve radical changes and which seem to offer great possibilities. The only present variations are details and simplifications which are special to the adoption of the welded construction. These details include the elimination of rivet holes, buttstraps, gusset plates, angles, fairing of plates and a reduction in the laps of the plates. The plates do not have to be fabricated excepting in so far as the rolling is concerned.



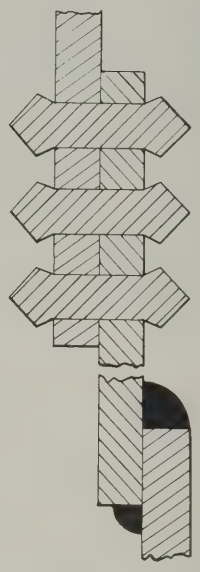
Partially Completed and Finished Tank. These Tanks are 15 ft. in Diameter and 16 ft. High and are Electrically Welded Throughout.

Further, inasmuch as the welded lap joints are of 100 per cent or more strength, the plates in the shell can be lightened 15 per cent. The result should still be a structure 10 to 20 per cent stronger than the present standard of riveted tanks.

The thickness of the bottom and top plates is determined by practice and until it has been demonstrated over a period of years that the corrosion of welded bottoms and tops is less than that of riveted bottoms and tops, it is doubtful whether it will be permissible to reduce the thickness of the plate of this portion of the tanks. The skin of the plates of bottoms and tops being practically unbroken, it is reasonable to assume that these parts will have considerably longer life than those of the present standard.

Portability

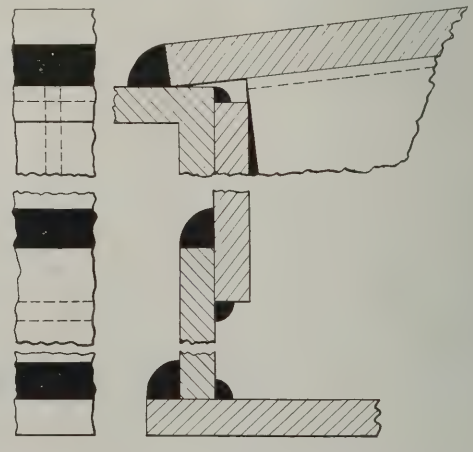
By applying the oxy-acetylene torch in such a manner as to destroy only the welding metal in the joints, it is possible to cut down welded tanks and erect them again in the same manner as is done with riveted tanks.



A Comparative Sketch of Riveted and Welded Construction Showing to What Extent the Overlapping is Reduced With the Welded Joint.

Engineering of Welded Tanks

At the present time, until standards have been developed for the welded construction of the various types and sizes of oil storage tanks, considerable engineering is necessary on each problem. Expert welding engineers are an absolute necessity for getting good results at the present stage of development of this phase of the art.



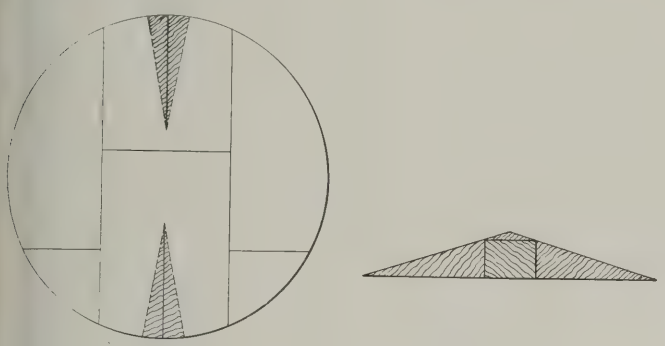
Type of Welding Used in the Construction of a 500-Barrel Tank. Sketches Show Roof, Sides and Bottom Welds.

It would seem a deplorable mistake if the users of oil storage tanks would decide to go in for this type of construction under their own guidance as it would, no doubt, give the electric welded design a set back such as welding got in Europe many years ago when some faulty welded containers in a power plant exploded,

causing considerable loss of life and damage to property. Welding at that time being a new art on the continent, it was universally condemned and this has been one of the main reasons why welding was not universally adopted on the European continent for years.

When such explosions happen on riveted containers the public simply feel that the engineers and the workmen on this particular job were at fault and do not think of condemning riveted construction in general.

These are some of the difficulties that a new art has to encounter. It would, therefore, seem that the conservative way of building up a welded design of oil refinery equipment, would be to turn this work over to expert organizations until the proper standards have been found.



Manner of Constructing Roof for a 500-Barrel Tank.

Advantages and Savings of Welded Construction of Oil Tanks

It will be years before the advantages of the welded construction can be fully determined. However, there would seem to be a few advantages which should be apparent now. The electrically welded tank is a homogeneous structure throughout and can be generally characterized as being a superior article to tanks built by any other means.

All joints throughout are 100 per cent strong.

The joints are absolutely tight and will stay tight over a period of years and after a number of temperature changes and after the tanks have been filled and emptied a number of times.

No initial strains are put on the bottom as it is welded in place.

The life of a welded tank must be estimated as being at least twice that of a riveted tank, for the reason that the skin of the plates is not broken and because the volume of the welds provides a much larger factor of safety against corrosion.

Welded tanks built on a concrete foundation can be set on this foundation without an intermediate layer or cushion. Riveted tanks will, if set directly on a concrete foundation, rest on the rivet heads and cause undue strains on these.

The electrically welded roof construction is gas tight and as is known, the saving in insurance premiums on gas tight roofs is considerable.

In fact, after the advantages of the welded construction have become more generally known, it is reasonable to assume that the insurance premiums on welded tanks will be lower than those on riveted tanks on account of reduced fire risk.

Paint will only be needed as the old paint is destroyed through age and weather. Painting on account of discoloration caused by seepage will be eliminated. In the refineries where tanks are painted white, the saving in the paint bill will amount to considerable.

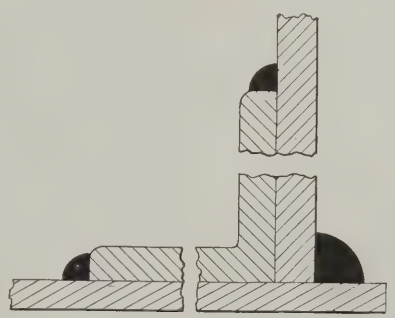
The saving in crude oil over a period of years by the use of these absolutely tight tanks will run into large amounts. The savings in volatile liquids from evaporation, seepage and leakage, can hardly be estimated and will, over a period of years, run into large sums of money.

100 Barrel Tank

Following is an outline used for the construction of one of the smaller tanks:

9 ft. diameter, 9 ft. high of 5.5 lb. plate (10 gage).
1½ in. laps throughout, welded from one side only.
No chipping and caulking.
The bottom and top are in two halves.
The shell in six vertical plates.
The plates rolled to shape.
The plates punched for bolt holes.
Two bolt holes every 30 in. and at the corners.
Welded with .134 in. diameter electrodes.
Current value about 125 amperes.
Average speed downhand welding 9 ft.
Average speed vertical welding 4 ft.

These tanks are erected by suspending an angle iron ring above the tank with six small blocks to catch each of the vertical plates and to hold them in place for bolting up and fastening to the bottom. Next, the top is put into place and bolted up. The tank is then laid on a cradle in a horizontal position and welded throughout from the outside only. The tank is turned so that all vertical seams of the finished tank are welded in a downhand position as well as the cross seams of the top and bottom. Leaving the tank on the cradle, the tank is turned as the work progresses. The circumferential joints between the top and shell, and the bottom and shell are welded in a vertical position, as are the fittings. The bolts are left in the tank and are welded to the tank from the outside.



Welded Construction Used in Joining the Sides and Bottom of a 5,000-Barrel Tank.

500 Barrel Tank

The important features of the 500 barrel tank construction are as follows:

15 ft. diameter, 16 ft. high of 5.5 lb. plate (10 gage) blue sheet steel.

1½ in. laps throughout, welded from both sides, excepting roof which was welded from one side only to make it gas tight. No strains on the roof.

Size of sheets 4 ft. x 11 ft.

No chipping and caulking.

The bottom and top are in three courses.
The plates were *not* rolled to shape.
Six bolt holes.
Welded with .134 in. diameter electrodes.
Current value 125 amperes.
Average speed downhand welding 10 ft. per hour.
Average speed vertical welding 5 ft. per hour.

The bottom plates were laid out flat on the foundation, which was graded in the usual way and welded from one side. After this was completed, the bottom was turned over and welded from the other side.

The shell was made in a different way from the ordinary procedure. Instead of being built in several courses, it was built in one single course, giving only vertical seams in the shell, on a barrel stave idea. The plates of the shell were laid out and welded together flat on the ground, so as to make two halves. One-half of the shell was then raised by means of a gin pole and one corner of it tack welded to the bottom.

The ends of a turn buckle were fastened to the outside ends of this half of the shell about half way up, by means of clips that were welded on to the shell. By tightening this turn buckle, the shell was forced into place and tack welded as it got into the proper position on the bottom. The other half of the shell was raised in a similar manner and tack welded into position.

This left the upper part of the shell out of shape. A cable loop was then put around the top of the shell. By tightening this, the shell was forced together.

A 6 in. I-beam on edge specially prepared with bolt holes, and the web removed where it was in way of the bolt holes, was fastened to the outside of the shell along with the length of the vertical shell seam. A similar I-beam was fastened on the inside of the same seam. There were three holes in each of these I-beams, and corresponding holes in the shell of the tank. With these I-beams, the edges of the shell were forced into position and welded.

After the vertical seams had been welded outside, the I-beams were removed and the inside vertical seams welded up. The bolt holes which were the only holes in the whole tank were then welded up. The joint between the bottom and the shell was made by setting the shell on the bottom, and consisted of one inside and one outside weld without any angle iron. The outside weld being the heavier.

A 2 in. x2 in. x ¼ in. angle iron was welded all around the top of the shell, heel and toe. The roof was welded in three courses. The ends of the center course were slit in the middle. A V-shaped piece being cut out at each end. A block 12 in. high was put under the middle of the center course, which gave the roof the proper pitch and in this position the slits were closed and welded up. This course was then put in place and welded to the top angle and the other courses lapped to the center course and welded to it and the top angle. There was no frame under this roof. The fittings were welded in the ordinary way.

This particular tank was filled with kerosene on completion and found absolutely tight without a leak or sweat of any kind and has been in constant use for seven months. Other similar tanks have also been successfully welded.

Following are some of the construction figures which apply to other welded tanks:

5,000 Barrel Tank

43 ft. diameter, 20 ft. high.
Bottom of 3/16 in. plate.
First course ¼ in. plate.
Second course 3/16 in. plate.
Third course 11/64 in. plate.
Fourth course 5/32 in. plate.
Roof 3/16 in. plate.
Size of shell plates 5 ft. x 14 ft.
1½ in. laps throughout, welded from one side in top and bottom, from two sides in the shell, the heavier weld being on the outside and in downhand position.
No chipping and caulking.
The plates were rolled.
Bolt holes every 36 in.
3/16 in. plate and over welded with .164 dia. electrodes.
Current value about 145 amperes.
Plates under 3/16 in. welded with .134 in. dia. electrodes.
Current value 125 amperes.
Average speed downhand welding 8 ft. per hour.
Average speed vertical welding 4 ft. per hour.

This tank was erected according to the standard for riveted tanks, in courses and each course was bolted together before being welded, by bolts every 3 ft.

A 2 in.x 2 in. x.¼ in. angle iron was laid on the bottom along this outside edge, leaving a ¾ in. space between the angle and outside edge of the bottom. The bottom inside flange of angle was welded to the bottom of the tank.

The first course set on the bottom and backed against the angle was welded to the bottom all the way around the side by a ½ in. weld. The angle was welded to this course from the inside by a ¼ in. weld.

A 2 in. lap between each two courses.

The outside welds were made for strength. The inside welds to seal the joint between the two plates.

The plates were scarfed where three plates came together.

The joints were simply welded in the ordinary way.

The top angle 2 in. x 2 in. x ¼ in. was welded heel and toe all around.

The roof was of the ordinary type of steel roof with a center and radial plates.

The angles and I-beams and roof construction were all welded in the simplest way, according to common practice, developed in structural welding work.

Welding on large tanks. From the amount of work done up to date, it has been definitely established that the same procedure can be followed in the construction of any size of tanks.

Acid Tank

Acid tanks of various kinds are being welded.
One acid tank was just completed.
10 ft. diameter, 15 ft. high, ⅞ in. plate.
Bolt holes every 36 in.
Plates rolled to shape.
About 3 ft. welded per hour.
Welded from the outside with a light sealing weld from the inside.

Agitator

24 ft. diameter, 30 ft. high.
Cone top and bottom.

All joints inside butted. All outside joints butt-strapped.
Bolt holes every 3 ft.
Width of butt-straps.
Width of butt-straps welded from the outside only.
Butt-joints welded from the inside.
The plates in courses, rolled to shape.
Welded with, 165 in. diameter electrodes.
Current value 125 amperes.
Bottom cone ½ in.
Shell ⅜ in., 5/16 in.
Top ¼ in.
Estimated time, average 4 ft. per hour.

Some Operating Results on the Norfolk & Western

THE question has been frequently asked why the Norfolk & Western Railway Company installed a steam-driven plant for power generation when hydro-electric power was available. At the time when plans for electrification were being perfected, this subject was studied in detail and the decision to generate by steam was arrived at after careful consideration. There were two main factors involved: first, the question of cost; second, continuity of supply. In 1913 and 1914, power station coal could be placed in the railway company's bunkers at less than one dollar per ton, and on this basis power could be produced more cheaply than it could be purchased. With the present high prices of this coal, the comparison is on an entirely different basis. As to continuity of power, hydro-electric concerns in the vicinity are affected materially by shortage of water at certain seasons of the year, and at the time electric operation was decided upon, very little steam reserve power was available. It was felt that it would be unwise for the railway to rely upon an outside source of power which was liable to interruption from shortage of water or other causes. The history of the electrification has justified the decision. Through the emergency connection with the Appalachian Power Company, the railway has frequently had to supply power to enable the hydro-electric company to maintain its service. For instance, in the month of June, 1920, the railway out of a total output of 8,768,000 kilowatt hours, furnished the power company 2,540,000 kilowatt hours, or about 27 per cent of the total. However, in the case of future extension of electrification, the situation will require careful study and consideration as to the possibility of a mutual arrangement whereby either party to the agreement would benefit from the available installed capacity of the other.

Contractual Relation with Power Company

In 1916, a reciprocal agreement was effected between the railway company and the Appalachian Power Company whereby, in emergency, either company would supply the other with power. Under the terms of this agreement, the power company installed at its own cost in its plant at Switchback, a frequency changer with connections to the railway company's substation at Maybeury. The amount of power which can be transferred is, of course, limited by the capacity of the frequency changer, which is 10,000 kilowatts. All power exchanged is metered at the power company's side of the apparatus and consequently the railway stands all loss of transmission and conversion. As a partial compensation, the power company paid for power supplied 33 per cent more than the railway company paid for power received. Payments originally were based on a flat rate per kilowatt hour.

Due to the great advance in cost of coal, a supplementary agreement was put into effect in 1918, whereby a sliding scale adjustment was applied to the price charged the power company to cover increase in cost of coal. No change was made in the price for hydro-electric power received from the power company, but provision was made that in the event of steam generated power being received from the power company from their steam reserve plants, the railway company would pay for this steam power on the same basis as the power company pays the railway. No adjustment has yet been made to cover increased cost of labor and material.

Under present conditions, the advantages of this emergency connection are slight insofar as the railway company is concerned. The amount of power available at any time is insufficient for traction purposes without keeping the railway company's Bluestone plant in complete operation. At times, it has been possible to use the power company's supply and shut down one machine.

There is, however, a distinct advantage due to the fact that the operation of the frequency changer can be handled so as to improve the system power factor of the railway. The use of the frequency changer as a condenser makes it possible to increase the power factor by 10 to 15 per cent.

Operation Costs

As the electric service now maintained is on an entirely different basis from the former steam service, it is impossible to give a direct comparison of cost. It has therefore been considered advisable to give the following comparison between steam and electric freight locomotive operation, using the records and figures compiled for use in the company's annual report. In this comparison, all costs entering into operation as well as interest and depreciation have been taken into account and while the figures are necessarily approximate, it is believed they are sufficiently close to be representative:

Comparative Cost Per Million Tractive Miles

Items	Steam	Electric
Interest and depreciation	$4.36	$12.16
Repairs	7.64	6.40
Fuel of electric power at locomotive	13.00	6.19
Lubricants and waste	.16	.05
Supplies	.16	.16
Engine house expenses	2.18	.56
Water	.51	.00
Wages	1.89	.70
Total per million tractive-miles	$29.90	$26.20
Per cent saving	12.5	per cent.

Attention is called to the unit of comparison, "Tractive-miles," which is the product of the maximum tractive power in pounds and total miles run. This affords a direct comparison.

In explanation of the table, it will be noted that the interest and depreciation figure for electric locomotives is much higher than that given for steam. This is because all of the electric cost has been charged against the number of engines in service, *i. e.*, each engine carries its share of power house transmission, distribution, etc. The actual electrification installation costs have been in-

*Abstract of the report of the Committee on Water Power for the Generation of Electrical Energy for the Operation of Trains. This report was presented at the 22nd annual convention of the American Railway Engineering Association, in Chicago,

creased in this table over 100 per cent to adjust the values to those prevailing in 1919.

The cost of electric locomotive repairs has been reduced below the actual figures in order to eliminate charges which have been due to the development of a new design. In other words, the electric locomotives now in service have been experimental, and could they be replaced today by new equipment it is entirely reasonable to expect the figures shown for repairs would be representative. In this connection it is pointed out that the power house, substations and transmission lines generally are designed for considerably larger service than is now given, or in other words, with the provision of three or four more locomotives and a relatively small expenditure in the power house the service could be much increased; consequently, the figure for interest and depreciation would be considerably reduced.

Conservation of Fuel and Saving in Wages

An important question today in connection with the general movement towards conservation of fuel is how much actual fuel can be saved by electric operation, and in this connection the Norfolk & Western Railway has found that with the modern Mallet, compound superheating steam locomotive, equipped with all improvements excepting feed-water heater, about 5.4 pounds of fuel are required per drawbar hp. hour, taking into account road conditions and allowing for standby losses. It should be noted that these figures assume the engine to be in thoroughly good operating condition. With electric operation, about 3.3 pounds of fuel are required per drawbar hp. hour in the present electric service, which gives a direct saving in the fuel bill of about 40 per cent. This amounts to a total saving for the present "Elkhorn Grade" electrification of about 60,000 tons of fuel coal per year. Applying the same ratio of saving to the whole Norfolk & Western system, it is estimated that with complete electric operation the net saving in amount of fuel used would be nearly one million tons per year.

In the case of crew wages, it will be noted that on the "Tractive-mile" basis the saving in crew wages is over 60 per cent. A comparison on another basis can be made by comparing the round trip times. The average round trip time for an electric crew between Bluefield and the coalfield is somewhat under seven hours, whereas the best average time under steam conditions formerly was somewhat over twelve hours. Therefore, to make a direct comparison, the seven crew hours in electric operation should be compared with fourteen hours in steam operation, taking into account punitive overtime. This in itself would show a saving of 50 per cent in the crew cost, but as there is of course a certain amount of overtime made by electric crews, the net saving is between 35 and 40 per cent.

One important point is that with the present facilities and volume of traffic, it is problematical whether the tonnage could be moved at all with steam. The only possible way to do so would be to increase the number of engines per train so that a schedule speed could be maintained equal to the present electric speeds. This would require probably four Mallet steam engines per train as compared with the two electric on the heaviest grades, which would increase the operation costs much beyond those shown in the table, and if the percentage of engine failures were at all unusual, the service would be unwarranted.

Mileage of Electric Locomotives

The total electric locomotive mileage made for the six months ending June, 1920, was 224,974, or an average of 34,162 per month. The average number of locomotives in service per day is about eight, which establishes an average figure of 135 miles per locomotive per day. In the case of individual locomotives, this is considerably exceeded.

Energy Per Locomotive and Per 1000 Ton-Miles

The company's records show that the kilowatt hours at the power house per locomotive mile are about 160, while the watt hours per trailing 1,000 ton-miles are about 165.

The Application of the Electrification of the Norfolk & Western Railway to Other Railways

In a general way the following statements can be made regarding the utilization of electrical energy for the operation of other railways similarly situated.

(1) That 44,000 volts, single phase, 25 cycle transmission of electric power with 11,000 volts, single phase on the trolley wire are practical and reliable voltages for electric train service for heavy grades and heavy tonnage.

(2) The average daily gross tonnage of freight eastbound over the electrified grade on the Norfolk & Western for 1918 was 47,500 tons as compared with 32,000 tons in 1912, an increase of over 50 per cent. The ultimate capacity based on the present installation is stated as 80 per cent over that of 1912.

(3) That such a system of electrification will probably effect a saving of at least 12½ per cent of the total annual expense as compared with steam operation on a railway with similar characteristics.

(4) That the introduction of electric locomotives with electric brakes (regenerative braking) has made possible higher speeds on heavy grades, with greater safety and reliability under all climatic conditions.

Hydro-Electric Plants Usually Augmented by Steam

An investigation of the larger hydro-electric installations east of the Mississippi River covering fifty-three plants discloses the fact that thirty-three are augmented by steam. In the majority of cases this is to care for the dry season. In considering future development for railway electrification, it is therefore reasonable to suppose that steam augmentation will be necessary in order to maintain sufficient power at all times.

Attention is called to the Water Power League of America, incorporated to promote the conservation of water power. The formation of this league should relieve this committee from attempting to report at large on this subject. From time to time your committee will advise the association concerning the activities of this league.

Radio Connects United States with Indo-China.—Plans have been completed whereby commercial radio messages may be sent from San Francisco via Hawaii, Guam and the Philippines to Hanoi or Saigon, in French Indo-China.

Machine Shop Lighted by 200-Watt Mazda C Lamps

Electric Lighting of Railway Buildings

Correct Illumination Resulting from Study of Requirements Is a Big Factor in Promoting Efficiency

By J. H. Kurlander
Lighting Service Department, Edison Lamp Works, Harrison, N. J.

IT would be difficult to find another industry where the use of artificial light finds such broad and diverse application as in the operation and maintenance of railroads. This is due to the wide scope of activities and to the fact that from its very nature operation in many departments is continuous throughout the entire 24 hours of the day.

Train lighting has had such attention devoted to it as to tend to make standard certain practices and also familiarize interested persons with them.

On the other hand, no attempt seems to have been made to coordinate the work done in other lines of electric lighting on the railroads. Each problem has been solved separately as it arose, with the result that few, if any installations, covering the same field are similar in nature. An effort will be made to combine data on current practices obtained from some of the leading railroads in the east so as to present it in an orderly and logical manner. Instead of drawing lengthy word pictures of the various subjects, photographs of actual installations supplemented by diagrams have been resorted to, with the hope that the subject, as a whole, will be rendered clearer and more concise, thus making the information readily available. The suggestions contained herein are practical, and not theoretical, as nearly all of them have been extensively applied in actual service. Where more than one method is applicable to a certain problem, the other methods are also presented, so that the one which best meets local conditions may be adopted.

Modern Lighting Practice

There are three fundamental considerations of a successful lighting installation. These are:

1. Intensity.
2. Quality.
3. Distribution.

For conducting work of any nature, light, either artificial or natural must be provided. For indoor work, either of these is somewhat costly to obtain. We ordinarily think of daylight as being free, but the windows placed in structures to secure it, cost more than the same amount of wall space, and even then, it is not always practicable to produce daylight in all spaces. When night comes, reliance is placed on artificial light for continuing our work. The proper amount provided by artificial means is often a debatable subject. We may argue at length as to whether two foot candles are all that is needed to carry on work satisfactorily, or whether three foot candles should be provided. Yet, during the day, the intensity of light received from the sun may vary from possibly one hundred foot candles one minute to forty foot candles the next, but either of these intensities is above that ordinarily provided by the artificial lighting system. Determination should be based on practice but modified as conditions change, and the lighting art advances. It is easily demonstrable, within the range of any existing practice, the more light provided, the greater the ease and rapidity with which work can be carried on. As we raise the intensity our seeing ability, our visual power increases also, until we reach

a point where a further increase in intensity will benefit our seeing ability but slightly. There is an economical limit above which the cost of raising the intensity would be out of proportion to the benefits derived, however, very few such cases have been noted, practically none under artificial illumination. The majority are well below the economical limit. Glare is sometimes confused with "over-lighting" and the rectification of so-called "over-lighting" is by reducing the apparent brilliancy of the illuminant and not by cutting down in the amount of light supplied. The benefits derived in the form of increased production from raising the intensity to that of so-called productive lighting, and increasing the efficiency of the process, would more than offset the expense of accomplishing this. The two primary benefits of a good lighting installation are greater production and safety. Increases of from 10 to 35 per cent in the production of the machine shops have been obtained by actual test where illumination has been raised from what is ordinarily regarded as good pratcice to higher levels, with an operating cost of less than 5 per cent of the payroll expense.

As we raise the standard of illumination, the second and third factors, quality and distribution, come more to the front. Quality means steady light of such a nature as to be comparatively free from glare and harsh-

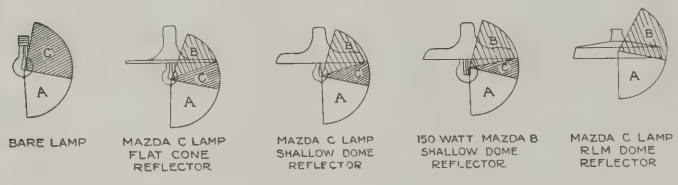

BARE LAMP
MAZDA C LAMP FLAT CONE REFLECTOR
MAZDA C LAMP SHALLOW DOME REFLECTOR
150 WATT MAZDA B SHALLOW DOME REFLECTOR
MAZDA C LAMP RLM DOME REFLECTOR

Fig. 1.—Showing Light Utilization with Various Combinations of Lamps and Reflectors. A—Direct Light Largely Useful. B—Reflected Light, Largely Useful. C—Light Tending to Cause Glare, Least Useful, Largely Wasted

ness, while desirable distribution means, light from the proper direction spread evenly over the working area so as to produce economical and effective utilization. The ultimate aim of the lighting is to make it easy to see objects. For proper perspective, the distribution of light should be such as to give natural shading which is not present under light of too diffuse a nature. While diffusion of a medium degree is necessary and should be encouraged, still it should not be carried to the point of rendering an object flat in appearance.

In spite of the efficient light sources available today in the form of mazda C lamps, some light users still cling to the old type of mazda B lamp above 60 watts. One reason for using these older type lamps is that they have been in service for a number of years, and the policy in such cases is evidently to use them until they burn out. Another reason advanced is that the filaments of these lamps are not so glaring as those of the mazda C type. Neither is a valid excuse for their continued use. In the first case, the slight expense involved in the purchase of a modern lamp is more than offset by the saving in power consumed and betterment in quality of light. In the second case, high wattage lamps of any sort, should not be used in such a manner that the unshielded filament is within range of the observer's vision. With modern reflectors and diffusing devices, the greater brilliancy of the more efficient lamp, does not stand in the way of its adoption.

A necessary adjunct to any efficient lighting installation is a durable reflector of proper design. The first requirement is very easily met, but some people do not understand what constitutes a proper design. In Fig. 1 are shown five sketches of possibilities in the way of lamp accessories. In the first place the reflector is conspicuous by its absence. This condition is a quite common one throughout industrial establishments and the sole reason for its existence seems to be that a reflector is sometimes looked upon as a liability and not an asset. The sketches illustrate quite clearly what happens when

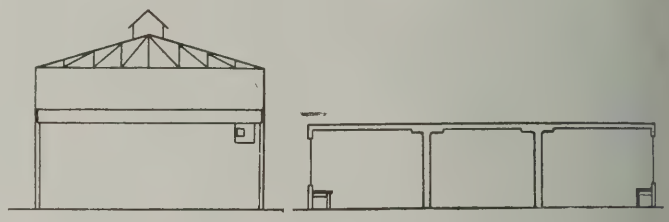


Fig. 2.—Characteristic Sections of Railroad Buildings

various combinations of reflectors and lamps are used. Reflectors serve not merely to redirect to the working plane, light which would otherwise be wasted, but also tend toward better lighting conditions by eliminating glare and protecting lamps from dust coatings and breakage.

Recommendations

All the principal industrial parts of the railway system with the exception of the round houses can be grouped as follows:

Group (A)—Buildings having the characteristic sec-

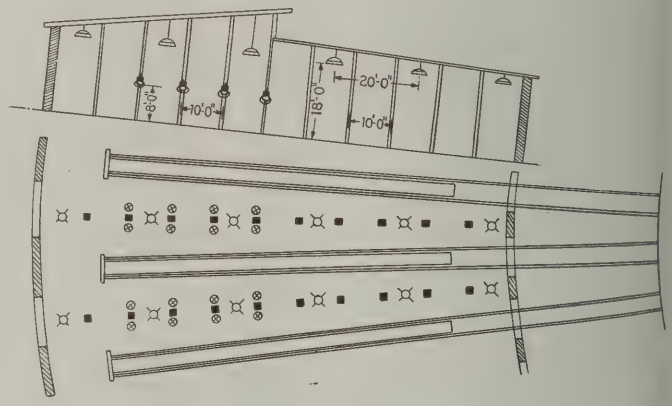


Fig. 3.—Plan of Roundhouse Showing Location of Outlets. Open Circles Indicate 200-Watt Mazda C Lamps in R. L. M. Dome Reflectors Mounted 20 Feet Above the Floor. Circles with Cross Represent 100-Watt Mazda C Lamps in Elliptical Angle Reflectors Mounted on Columns 8 Feet Above the Floor

tion shown in Fig. 2 with high ceiling. These include erecting shops, foundries, car shops, etc.

Group (B)— Those with low ceilings as follows: machine, tank, paint, wheel, forge, carpenter shops, etc.

Roundhouses

The lighting of this type of structure presents a rather difficult problem, inasmuch as the interior is commonly filled with dense clouds of smoke and gases. The smoke acts as a screen tending to prevent light from the units reaching the working plane and the acid and gases attack all exposed metal work of the lighting installation, thus making the cost of upkeep relatively high. The

roundhouse serves as a stable for engines awaiting duty, and minor repairs on the engine are made here. A great deal of work is performed at the head and sides of the engine and the best light is needed at these points. Little or no work is done on the tender and consequently, the passageways between stalls need only sufficient illumination to ensure safe walking conditions. One important repair effected at the roundhouse is that of the turbo-generator set. If the overhead units are hung too low, this machine will be left in darkness which will necessitate using a local lamp or hand torch.

Fig. 4.—Night View of Roundhouse Lighted by the Combination of Overhead and Angle Units. In Spite of the Smoke the Intensity is Such as to Facilitate Rapid Work on the Locomotive

There are two general systems in vogue for lighting roundhouses. One makes use of flood-lighting projectors mounted down the passageway between stalls toward the turntable. This method, while giving a good intensity upon the work, has the objection that it is glaring and the light is not diffused. It has a predominant direction, with the result that there are sharp shadows and a person with his back to the light would be likely to cast a shadow directly on the work. The light does not penetrate well into the mechanism at the side of the locomotive.

The other plan involves the use of high wattage lamps suitably placed in efficient reflectors and uniformly spaced down the passageways. In addition to this, angle reflector units are mounted on the columns approximately eight feet high projecting the light horizontally on the engine's sides. Fig. 3 shows this arrangement in detail and Fig. 4. shows a night view taken of such an installation.

The hydrogen sulphide gas emitted by locomotives combines with steam, which, when deposited on exposed metal work forms sulphuric acid. This results in rapid deterioration of the metal. For this reason, exposed conduits in roundhouses have but a short life, and unless some means is taken to limit the scope of this action, the cost of maintenance will soon be out of proportion to that of the rest of the installation. One of the best methods for limiting this corrosion of the conduit is to run the major portion of the circuit either on top of the roundhouse roof or else embed it in the concrete roof where such construction is employed. If wiring is placed on the roof, it should be given a good coat of some suitable weather-proofing paint to prevent its being attacked by rain, snow or moisture. The vertical section of conduit used for supporting the lamp and reflector would necessarily have to be replaced when corrosion advanced to such a stage as to render this replacement necessary.

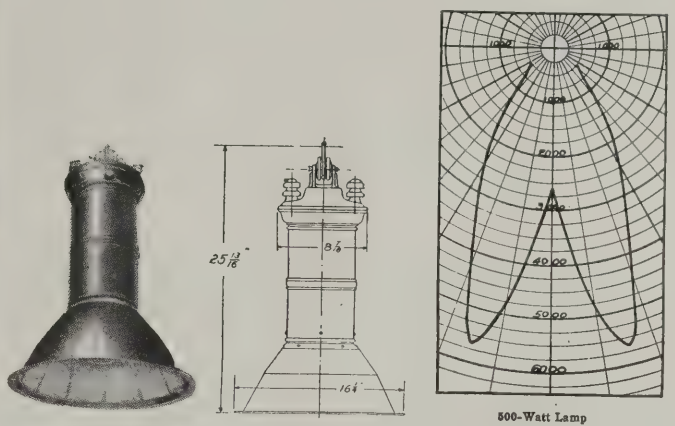


Fig. 5.—Industrial Lighting Units for High Hanging

These vertical sections of conduit can be threaded on one end which will allow of their being unscrewed from the main section, and a new section being installed. Another method is to run the feeders and branches approximately four or five feet below the roof of the roundhouse, in order to place them below the level of the gases accumulated under the roof. The conduits in this case also should be given a good coat of paint. These methods of protecting wiring circuits have already found wide application.

Convenience outlets should be placed at frequent intervals on side walls and columns in such a manner that portable extension lamps can be used with little danger of injury to workmen due to stumbling over such cords. For protecting the cord itself, it would be well to use some form of armored cable.

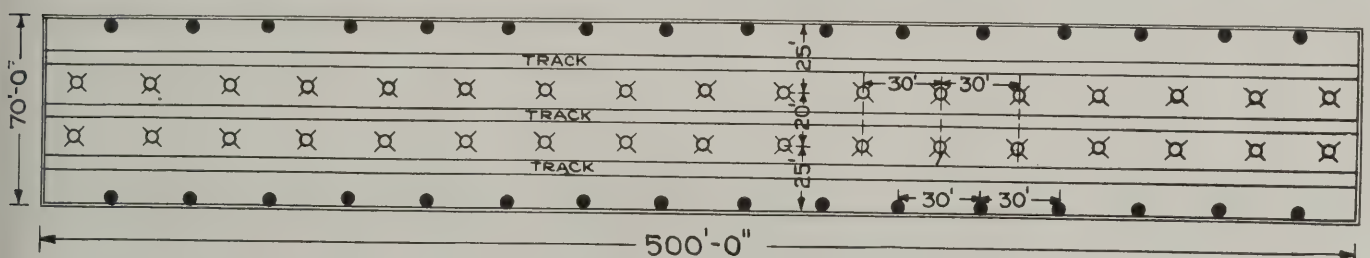


Fig. 6.—Plan of Erecting Shop Showing Location of Units. Open Circles Represent 500-Watt Mazda C Lamps in R. L. M. Dome Reflectors and Black Circles Indicate Same Type of Lamps in Elliptical Angle Reflectors

Erecting Shop

As shown in Fig. 2, the lamp locations in this shop are limited by the overhead cranes. The work is of a

fairly coarse nature inasmuch as large metal parts are handled, assembled or taken apart, and except for occasional fittings, no very exacting demands as to lighting exist. Illumination on vertical surfaces must be as good if not better than that on horizontal planes in many cases, and light must penetrate in nooks and corners not often encountered even in machine shop work. There are some places where local lights, either of the portable incandescent lamp type, or a hand oil torch, must be used. Where work is being performed on the inside of the boiler, a local or portable lamp is indispensable. A fairly high intensity is desirable in order to speed up work on the engine so as to enable it to leave the shop in first-class condition at the earliest possible moment.

When considering the type of installation for this class of structure, it will be easily seen that there are two general methods applicable, one makes use of high wattage overhead units in either deep bowl or RLM dome reflectors; the other makes use of special industrial lighting units, Fig 5. The use of the latter type is required only in places having exceedingly high ceilings or where the atmospheric conditions are such as to absorb a large percentage of the light from overhead units. The average erecting shop, however, can be lighted by

Fig. 7.—Night View of Erecting Shop Lighted by Two Rows of 500-Watt Mazda C Lamps in R. L. M. Dome Reflectors Spaced on 20x30 Foot Centers Down the Center of the Shop and 500-Watt Mazda C Lamps in Elliptical Angle Reflectors Spaced 30 Feet Apart Hung on Each Side Wall

two rows of either 500, 750 or 1000 watt units in RLM dome reflectors running down the center of the shop and one row of elliptical angle reflectors containing 500 watt mazda C lamps mounted on each side wall (see Fig. 6) in order to give good illumination on vertical surfaces. Fig 7 shows an erecting shop lighted by such an installation.

For small erecting shops with ceilings approximating those of the average factory room, a method which gives good results is to run a line of 200 or 300 watt Type C lamps in RLM dome reflectors down each aisle between tracks, as illustrated in Fig. 8. Convenience outlets should be provided at frequent intervals.

Car Shops

The machine work performed in these shops, such as punch-pressing, trip-hammering, welding, general assembling, etc., does not require a great deal of light for its performance. The building used for this work is characterized by a width of from 50 to 80 feet, a great length and high ceiling. Local lighting is unnecessary, save when working on car interiors and for this convenience outlets and well shielded portable lamps should be part of the equipment. General lighting should provide a medium intensity over the entire floor surface, preferably from high wattage Mazda C lamps in deep bowl metal reflectors, supplemented by smaller lamps in angle

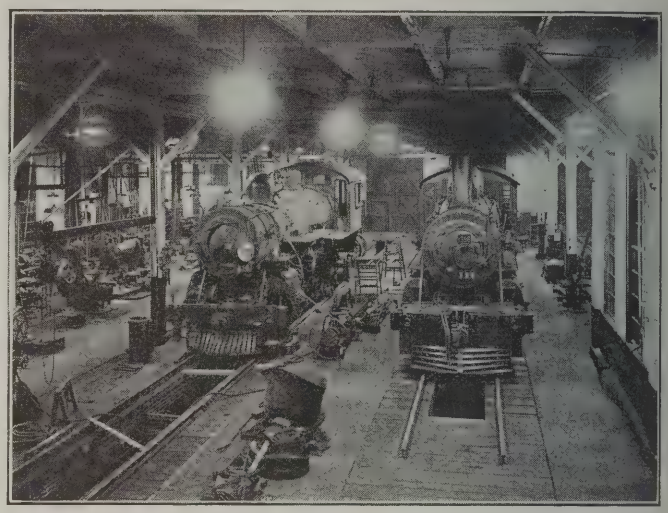


Fig. 8.—Night View of Erecting Shop Lighted by 400-Watt Mazda C Lamps in R. L. M. Dome Reflectors Hung 17½ Feet High and Spaced on 15-Foot Centers

reflectors mounted on the side walls. The electric crane always present in this type of shop makes necessary a high hanging, in the neighborhood of 30 feet. Fig. 9 shows a section view of a car shop and positions of units.

Foundries

In foundry work, one encounters conditions somewhat different than the other shops discussed. There is always

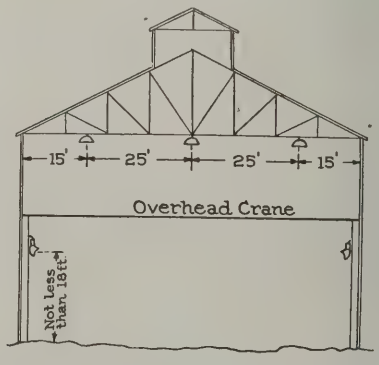


Fig. 9.—Section of Steel Car Repair Shop Showing Location of Units. 500-Watt Mazda C Lamps in Deep Bowl Reflectors and 200-Watt Mazda C Lamps in Elliptical Angle Reflectors

present, more or less of a haze, due to the presence of smoke, which tends to absorb the light from the overhead units. Then again, good diffusion is necessary as all parts of the mold should be distinctly visible for the purpose of effecting repairs to breaks or cracks in the mold. Where the light has a predominating direction such as straight downward, shadows are apt to be cast by edges of the mold leaving the sides at the point in-

volved in darkness, thus hiding a possible mar in the mold. In order to overcome this, a system similar to that employed in the erecting shop should be resorted to, using overhead high wattage mazda C lamps in dome reflectors and similar lamps in angle reflectors, mounted at the same height on the side walls. The cross rays of

Fig. 10.—Wheel Shop Lighted by a General System of 400-Watt Mazda C Lamps in R. L. M. Dome Reflectors Spaced 17x15 Feet and Hung 17½ Feet High

light will tend to break up any shadows caused by the overhead units. This system has been tried out and the results found very satisfying.

Group "B"—Shops

Machine, Forge and Wheel Shops, Etc.—The shops grouped under this heading are contained in rooms ap-

Fig. 11.—An Up-to-Date Forge Shop Lighted by 200-Watt Mazda C Lamps in Shallow Dome Reflectors, Spaced 20x30 Feet and Hung 15 Feet High

proximating those of the average factory. The lighting of them, therefore, becomes a problem similar to that of the ordinary industrial plant. There are few, if any, cases where a straight general system cannot be employed to good advantage. There may be times, however, when local lighting will be necessary, such as when painting the interior of cars and over certain machines found in the tin or metal shops. In the former cases, the general custom seems to be to place a bare 75 or 100 watt mazda C lamp directly behind the operator. These lamps have small hooks fastened to the socket which enable them to be hung from the roof of the car and as the lamps are behind the operator, glare does not result to any great degree. However, the danger lies in that the lamp of a neighboring operator may be objectionable. An angle reflector, so fastened that it cannot swing about, on such a lamp will conserve light and reduce glaring interference.

The shops in general should have an even spacing of overhead units on centers such as 12 x 12, 15 x 15, etc. The hanging height in any case, should range from between 10 and 18 feet. The greater height is preferable if it can be obtained.

A glance at the machine shop photograph shown at the beginning of this article will convince one that the lighting of this shop is of the first order, but even the most casual inspection will reveal one feature that is most uncommon in railroad machine shop lighting. This is the entire absence of local lights. Machine operators are slowly being weaned away from the idea that local lights are indispensable to their work. There are several instances, to be sure, where such a light must be used, but a great majority of the operations do not require one.

Under this general heading come two shops which usually are so sadly neglected that it was deemed advisable to accord them special attention. One is the forge shop and the other the wheel shop. The wheel shop shown in Fig. 10 possesses no unusual characteristics and is lighted by a simple overhead system employing type C lamps in deep dome reflectors. The entire shop, however, is lighted almost as well by night as by day.

In Fig. 11 is shown a forge shop which differs radically from most such shops. Not only is the lighting very good, but the conditions which influence this to a great extent have also received consideration. The painting of the forges to make them reflect the maximum of light is a practice which is finding greater application each year, not only in this class of shop but in others also, particularly machine shops.

A Rack Rail Section on the Chilean State Railways

Principles of Car Lighting By Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

XII.—Testing and Adjusting a Car Lighting Equipment

THE most important requirement in testing and adjusting a car lighting equipment is, to have the testing instruments correctly calibrated. In other words, all voltmeters, ammeters, hydrometers, thermometers, etc., should be checked with a standard before each test.

Each car lighting equipment consists of three main parts: the battery; the generator; and the regulators. The testing and adjusting of these main parts may be treated separately.

Battery Testing

In testing a battery the operator must have the necessary knowledge to enable him to know from the various

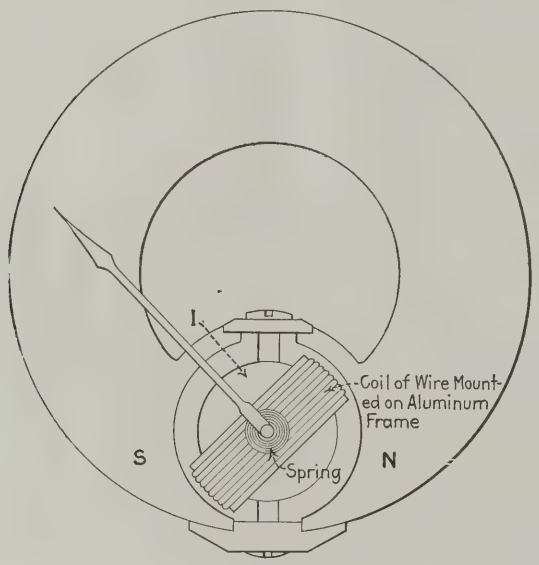


Fig. 1.—The D'Arsonval or Moving Coil Type of Instrument.

electrical and chemical indications whether or not the battery is in a healthy condition. For example, an hydrometer reading of the electrolyte would not have any meaning whatever without the knowledge of the variation of the specific gravity on charge and discharge. Likewise, a temperature correction of the hydrometer reading could not be made, if you did not know the influence of temperature upon that particular solution. Therefore, in explaining the method of testing a battery, a few points will be included to indicate what correct battery performance is. To thoroughly test a battery, it should be removed from the car to a bench in a test room properly equipped for this particular work. When this is done, the battery should receive a cycle of charge and discharge, during which, the following should be noted:

1. Height of solution.
2. Individual cell voltage.
3. Individual cell specific gravity reading.
4. Individual cell temperature readings.
5. Individual cell cadmium readings.
6. Rate of charging and discharging current.
7. Hours of charge and discharge.

Before running this test you should know:

1. The correct capacity of a battery of this type.
2. The correct variation of cell voltage of such a battery.
3. The correct variation cadmium reading of such a battery.
4. The correct variation of the specific gravity of the electrolyte.
5. The normal charging and discharging rate of this particular type of battery.

For testing a lead storage battery, the following instruments are required: *Voltmeter, ammeter, hydrometer syringe, thermometer,* and *cadmium test piece.*

The volt meter should be of the D'Arsonval double scale type, with scales preferably as follows:—

High scale 0-150 volts, graduated to 1 volt per division.

Low scale 0-3 volts, graduated to .02 volt per division.

The ammeter should also be of the D'Arsonval type with scale graduated, 0-150 amperes, 1 ampere per division.

The hydrometer syringe should be graduated to read from 1.150 to 1.300 specific gravity, and the thermometer should read from 0 deg. F. to 120 deg. F. For the benefit of those who are not familiar with the D'Arsonval type instrument, a brief description may be of interest. The D'Arsonval or "moving coil" type of instrument is more accurate than other types. At the same time it is more delicate and is more difficult to manufacture. The principle of the instrument is shown in Fig 1. Placed between the north and south pole of a magnet is a coil of wire mounted on a light aluminum frame. The coil is attached to the wire carrying the current to be measured through light springs, and when the current is sent through, one end of the coil becomes north and the other end south. Then according to the magnetic law, the south end of the coil seeks the north pole of the magnet and the pointer, attached to the frame passes across the scale. The "dead beating" or "damping" of this type of instrument depends on the strength of the magnetic lines of force (which is increased by the introduction of the iron core *I,* and careful grinding of the pole faces). Eddy currents are set up in the aluminum frame which have a tendency to retard its movement and consequent deflection of the pointer. The D'Arsonval is perhaps the oldest type of electrical measuring instrument in use today. If carefully built, it is extremely accurate and dependable, although rather delicate.

In placing the battery on charge and discharge, it is connected in circuit as shown in Figs. 2 and 3. Note that on charge the positive side of the battery is connected to the positive side of the source of charge, and the negative side of the battery is connected to the nega-

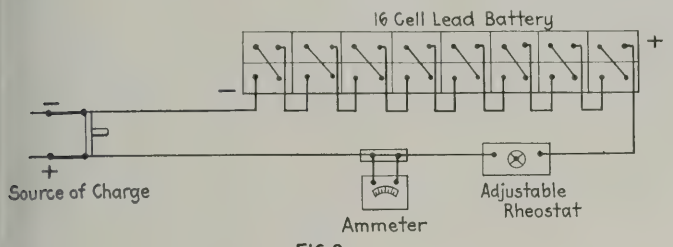


FIG.2.

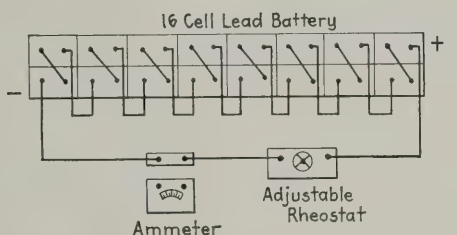


FIG.3.

Fig. 2.—Battery Connected for Charging.
Fig. 3.—Battery Connected for Discharge

tive side of the source of charge. In taking cell voltage readings, the voltmeter is conected across the terminals of the cell while in taking cadmium readings one side of the voltmeter is connected to one of the battery terminals and the other side of the cadmium test piece which is submerged in the electrolyte of the cell, Fig. 3A. The specific gravity of the electrolyte at the end of charge should average 1.220. If necessary, the specific gravity of the electrolyte should be adjusted at the end of charge. During charge, the temperature should be watched very carefully and should not be allowed to exceed 110 deg. F. When the temperature approaches this point, the charge should be discontinued until the cells have cooled down. The cell voltage at the end of charge with normal charging current flowing should be 2.6

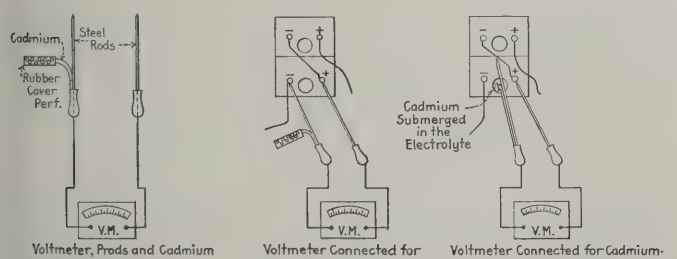


Fig. 3A.—Method of Taking Cell Voltage and Cadmium Readings.

volts per cell. In making a test discharge, readings should be taken of the individual cell voltages every hour until one cell has dropped to 1.8 volts, and then at fifteen minute intervals until the voltage of the battery as a whole has dropped to an average of 1.8 volts per cell. Any cells which show less than normal capacity and drop out considerably in advance of the balance of the cells should receive immediate attention.

The Cadmium Test Piece.—The cadmium test piece must be free from impurities and its surface should not be scraped bright, on the contrary it should be aged, that is, covered with a layer of cadmium sulphate. Also, while using, the cadmium must not come in contact with any of the plates or connections, and the best way to prevent this is to cover the test piece with soft rubber tubing, this tubing to have numerous small perforations. When not in use the cadmium test piece should be kept immersed in dilute sulphuric acid, or at least immersed in such acid for a few hours before using. The reason for this is that there is a difference of potential between cadmium and cadmium sulphate and the bright surface sulphates so quickly that it would be necessary to scrape

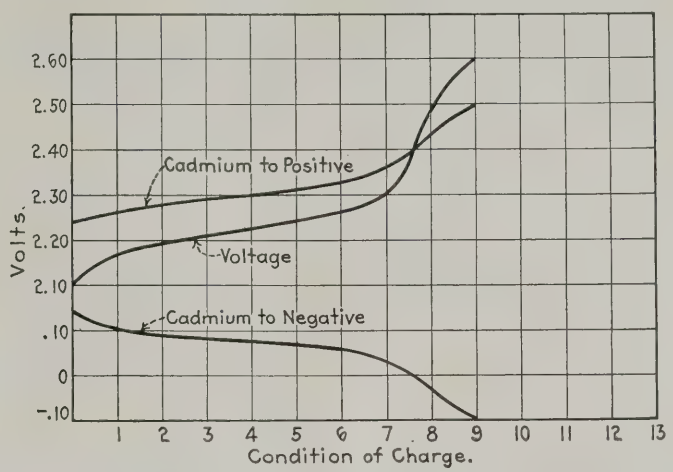


Fig. 4.—Cell and Cadmium Voltage During Charge

the test piece before each reading if comparable results were to be obtained. When a new battery is completely discharged, and normal current flowing, the test reading should be as follows:

Positive plate and cadmium, not lower than 1.98 volts; negative plate and cadmium, not higher than .18 shown by the voltmeter; and the voltage of the cell being the difference between these readings. When a new battery

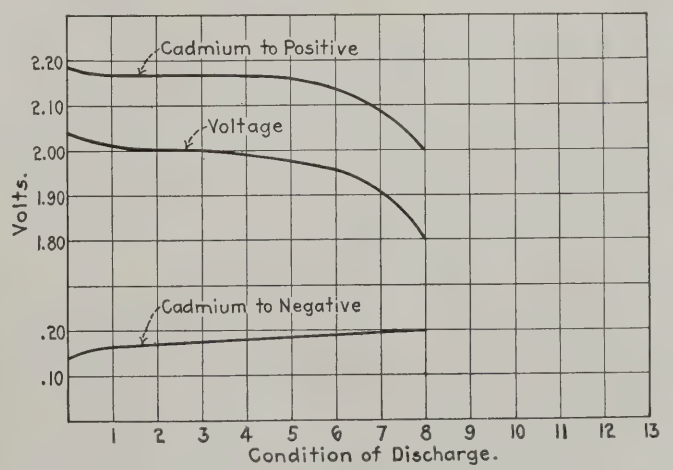


Fig. 5.—Cell and Cadmium Voltage During Discharge

is completely charged and normal charging current flowing the test readings should show as follows:

Positive plate and cadmium, about 2.45 volts; negative plate and cadmium, .14 and .16 volt, the cadmium being negative to the positive plate and the positive to the negative plate as shown by the voltmeter and the

voltage of the cell being the sum of the readings. It will be noted that as a battery proceeds from a condition of discharge to charge that the cadmium is first negative to the negative plate and near the end of the charge becomes positive to the negative plate.

Figs. 4 and 5 show the conditions that obtain, Fig. 4 being that of charge and Fig. 5 being that of discharge, both being for a new battery at the eight-hour rate under normal conditions.

It will be noted that the sum or difference of the cadmium readings equals the cell difference of potential, as the case may be, though in practice it is somewhat difficult to measure these voltages sufficiently accurately to make these check exactly on account of the small deflection produced between the cadmium and the negative plate and variations in the location of the cadmium test piece at successive readings.

As the negative plates grow old they usually lose capacity, on account of the shrinkage of the active material closing up the pores. To allow for this falling off in capacity the negative plates are usually manufactured with an initial capacity in excess of that actually required. An old negative plate is considered to have normal capacity when the cadmium reading at end of discharge has a value not exceeding .30 volt at the normal discharge. Note that on discharge and particularly at end of discharge, the lower the cadmium negative reading, and the higher the cadmium positive reading, the greater the capacity of the plate. An example will show how the cadmium readings are used to determine the condition of the plates.

Suppose that the voltage of the cell while being discharged at the eight-hour rate has dropped to 1.80 volts at the end of five hours and that the cadmium reading for the positive plates is 1.95 volts and for the negative plates .15 volt. In this case, the capacity of the negative plates is considerably in excess of the limit, while the positive plates are exhausted.

This indicates either lack of active material on the positives or that all of the sulphate has not been converted into peroxide, that is, that the battery has not been fully charged. It is therefore advisable to make a second test, first making sure that the battery is fully charged. If the capacity remains the same and it is apparent that the plates are otherwise in good condition it will be necessary to renew the positive plates unless the capacity as obtained is sufficient for the requirements of the service.

If the cell voltage is 1.8 at the end of five hours and the cadmium reading for the positive plates 2.12 volts and for the negative plate .32 volt, it indicates that the positive plates are good and that the negative plates are lacking in capacity. In this case the negative plates, if of the Planté type, can be brought up to proper capacity by reversing.

Bringing Negative Plates up to Capacity.—Negative plates, as they age, have a tendency to lose capacity, due to the shrinking of the active material, which, by closing up the pores, interferes with the diffusion of the electrolyte.

The same effect occurs if there are impurities in the electrolyte which may act either to produce "local action" or clog the pores of the active material. To overcome these defects and again place the element in good condition, they are reversed in the following way: Charge the battery fully and then remove the negative plates, placing them in tanks filled with 1.240 specific gravity electrolyte and connect them as anodes, that is, in a reverse manner to which they are normally connected. As cathodes, dummy plates of plain sheet lead about 1/16 in. thick can be used. The tanks should contain as much electrolyte as possible, as it must be as cool as practicable. The plates should be charged at double the normal eight-hour rate until they gas freely and the charging rate may then be gradually reduced to normal, and continued at the latter rate until the active material is thoroughly reversed and converted into lead peroxide, the sponge lead turning first to $PbSO_4$, then to PbO_2, as the action continues.

Toward the end of the reversal, the cells may be open circuited for a few minutes; then if on closing the circuit the plates immediately begin to gas, the reversal is complete. If gasing does not immediately take place, however, it is proof that the reversal is not complete and that only the surface of the crystals of the active material has been covered with a layer of lead peroxide, and that on open circuit the lead peroxide discharges into the metallic lead of the crystals underlying this layer. It requires a continued application of current to convert this sulphate again into lead peroxide. The plates having been completely peroxided, they are set up with new dummy plates and fresh acid and connected in the usual manner and current passed through them as before, the best value for the current in this case being the normal rate. When finally converted back into spongy lead and reassembled with the positives it will be found that the capacity of the negatives has materially increased.

New dummy plates and fresh acid are used so that any impurities thrown off will not be redeposited on the plates.

Electrolyte.—The electrolyte used with storage batteries of the lead type consists of dilute sulphuric acid, of a specific gravity of 1.200 to 1.300, depending on the amount of electrolyte and the construction of the battery. It should be free from all impurities such as hydrochloric, nitric or acetic acids, or such acid forming compounds, iron, arsenic, antimony, copper, mercury, or the slightest trace of platinum.

The specific gravity of the electrolyte used in standard car lighting batteries must be maintained between the limits of 1.215 and 1.225 with the battery in a fully charged condition. The density of the electrolyte is dependent on the proportions of acid and water, or in other words, upon the amount of the dilution of the acid. It is measured by means of an hydrometer. For variation of specific gavity on charge and discharge, see Fig. 6

The density of the electrolyte has an important bearing on the operation of the battery. If it is too high, sulphating is accelerated and the plates depreciate more rapidly. The resistance of the electrolyte is at a minimum at about 1.235 specific gravity, rising if the gravity be either increased or decreased. The density is expressed in terms of specific gravity, that is, the ratio of the weight of the electrolyte to the weight of the same volume of water, or in terms of some arbitrary scale. In speaking of the specific gravity of electrolyte, it is usually referred to as a whole number, thus 1.215, 1.220, 1.225 specified gravity is spoken of as 1215, 1220, and

1225. As the temperature of the electrolyte influences its density, and the density in turn affects the resistance of the electrolyte and the capacity of the battery, the electrolyte should be corrected for temperature. The following table gives the proper specific gravity of the electrolyte for various temperatures, the readings in all cases being that of the electrolyte at end of charge:

Degree, Fahr.	Specific Gravity.
106	1.208
97	1.211
88	1.214
79	1.217
70 Normal	1.220 Normal
61	1.223
52	1.226
43	1.229
34	1.232
25	1.235
16	1.238
7	1.241

It will be noted that the correction is approximately 1 point for each three degrees F. difference from normal temperature which is taken at 70 deg. F.

Warm electrolyte should never be used in a cell as it accelerates the injurious effects produced by other causes, and shortens the life of the plates.

Correcting Specific Gravity.—When testing the specific gravity of electrolyte with a view of correcting same the following method should be used: Fill the cell with distilled water to normal level, and place on charge. When fully charged, test the temperature and specific gravity and add sufficient acid or distilled water as may be necessary to bring the specific gravity to 1.220, when corrected for temperature.

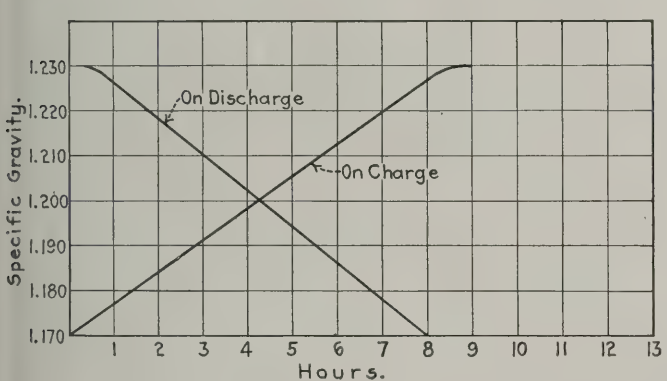


Fig. 6.—Variation of Specific Gravity on Charge and Discharge.

When the electrolyte is found to be impure, due to the presence of any metal other than lead or any acid other than sulphuric, it must be immediately drawn off and fresh electrolyte applied, and such other action taken as may be necessary.

When diluting the acid, the acid should always be poured slowly into the water, and not the water into the acid. The reason for this is that a chemical combination is formed, which liberates heat, thus raising the temperature of the electrolyte, and if the water is poured into the acid the action is more rapid than if the acid be poured into the water, and the electrolyte is more liable to splash and burn the operator's person or clothes. The electrolyte must be allowed to cool before using. After cooling the specific gravity will be found greater than when hot, but can be corrected to the proper density by the addition of a little distilled water. It is essential that the water used to dilute the acid or electrolyte should be free from all impurities and only distilled water should be used for this purpose. Water obtained by condensing steam from a steam boiler should not be used, as it is liable to contain oil, or chemicals used in purifying the water for boiler purposes. The water should be obtained from a still and condensed in a block tin or lead pipe.

All corrosive actions of liquids on solid substances immersed in them take place with the greatest rapidity at the surface of the liquid, and battery plates which project above the electrolyte deteriorate much more rapidly at this point than the submerged portion. This action can be rendered of small importance by keeping the plates always completely covered with electrolyte and making the lugs which pass from the plates to the terminals, of thick, dense lead. The normal level of the electrolyte is approximately 1 in. above the top of the plates.

Testing an Edison Battery.—The instruments used for testing a lead battery are also used for testing the Edison type with the exception of the cadmium test piece, which is used only with the lead battery.

The Edison battery is connected for charging and discharging in the same manner as shown for the lead type in Figs. 2 and 3.

The range of voltage of an Edison cell during a normal seven-hour charge is from 1.6 volts per cell minimum to 1.8 volts maximum.

The range of voltage of an Edison cell during a normal 5-hour discharge is from about 1.4 volts per cell maximum to 1 volt per cell minimum.

The electrolyte of an Edison cell is a 21 per cent solution of potash, *KOH,* in distilled water with a small per cent of lithia having a normal specific gravity of 1.220 at 70 deg. F.

The specific gravity reading of the electrolyte of the Edison cell should also be corrected for temperature. The correction for this solution is approximately 1 point for each 5 degrees F. difference from normal. The height of the solution in an Edison cell varies with the different types of cells. The proper height for an A-8-H cell is 2¾ in. above the top of the plates, and for an A-4-H cell 3 in. above the top of the plates.

Testing Axle Generators and Regulators.—A newly installed, as well as a periodically overhauled or repaired, axle generator equipment should be tested and adjusted prior to being placed in service. As with the battery, nothing but correctly calibrated instruments should be used, and these instruments should be tested with a standard before each test. If the regulators are conveniently located inside of the car, it is not difficult to make adjustments while the car is operating on the road, but even this flickering of light is annoying to the passengers and has other objectionable features. Where the regulators are located under the car body some other method of testing is required and a very interesting problem is presented. Various schemes have been adopted, a few of which are:

1. Driving the generator by a portable motor mounted on a truck. The motor and generator connection being

made by means of a flexible shaft which is connected to the generator armature shaft by removing the armature pulley.

2. Driving the generator by a motor located in a pit under the car. The drive consisting of a belt and two pulleys.

3. Removing the generator and regulators from the car to a test room, where the regulators are placed on a rack and the generator belted to a motor on a test block.

The instruments used in testing a generator are voltmeter, ammeter, and thermometer. In testing an axle generator equipment the following should be considered:

1. The commutation with rotation of armature in both directions.

2. Activity of pole changer, upon change of direction of rotation.

3. Temperature of bearings, coils, etc.

4. Generator current, light on.

5. Generator current, light off.

6. Operating current of series solenoid on generator regulator.

7. Generator voltage.

8. Automatic switch operating voltage.

9. Potential solenoid operating voltage.

10. Lamp voltage, generator operating.

11. Lamp voltage, generator not operating.

12. Freedom of movement of regulator parts; as dash pots, plungers, plunger arms, at various speeds of armature rotation.

13. *Test for grounds with a voltmeter.*—To read the generator voltage, the voltmeter is connected across the main generator circuit at the bottom of the generator regulator panel. At this point the automatic switch and potential solenoid operating voltage may also be read.

In making ground tests, connect the positive side of the voltmeter to the positive side of the circuit, and the negative side of the voltmeter to ground. A voltage reading will then indicate a negative ground. Interchange the meter leads, connecting the positive side of the voltmeter to the ground and the negative side to the negative side of the circuit. With these changed connections a reading will indicate a positive ground.

It is essential in making regulator tests to be familiar with the battery charging curve for that particular equipment, and also to allow the temperature of the coils to reach the operating point before attempting to make adjustments.

It is the practice on the various railroads to inspect the car lighting equipment on each car upon arrival. To make a test of the battery generator and regulators, as above described upon each arrival would be impracticable. Therefore some means must be used to determine the condition of the equipment as near as possible without interfering with the operation of the train. One scheme is to note the temperature of the regulator coils upon arrival. If they are warm it is an indication that the generator has been operating. If they are cold the generator is in trouble. In the latter case, the generator is given the motoring test. This test consists of removing the belt from the pulley and operating the generator as a motor from the battery by closing the automatic switch by hand. The machine is started with full field and is brought up to maximum speed by increasing the field resistance with the carbon pile on the regulator panel. At maximum speed the field resistance is suddenly reduced to a minimum, and the automatic switch released. The momentum of the armature revolving in a strong magnetic field causes the automatic switch to close automatically, indicating that the machine is acting as a generator. This test will sometimes locate the trouble, but not always. If, however, the motoring test fails to show the source of trouble, then it is necessary to give the equipment a thorough test as previously described.

A check is made on the condition of the battery upon each arrival by noting the ampere hour reading and also by taking a voltage test of the battery with the lamps burning. This voltage test is practiced, not because it is the best indication of the battery as to state of charge, but because it is the only practical test that can be made without involving considerable expense and interference to the train movements.

Electro-Percussive Welding

PRODUCTION of large quantities of duplicate parts which require welding has been found to be expedited by the electro-percussive process of welding. The apparatus consists essentially of a device for producing a percussion of the parts to be welded simultaneously with a discharge of electrical energy, the energy being taken from a condenser or a magnetic field. Use is made of electrolytic condensers charged by direct current of low value, or an arrangement is used, utilizing the energy stored in a magnetic field and discharged through the parts to be welded at the moment of weld. The discharge takes place between the points to be welded with explosive violence, and at that instant the hammer forges the parts together into a perfect union. The time of fusion and union of the parts is only approximately 0.0095 second. The time sequence of events shown in an oscillogram taken during a weld between ⅜-in. copper and steel rods indicated a peak current of 2,600 amp., an arc voltage of 30, a maximum power of 60 kw. and an energy consumption of 0.00077 kw.-hr. The time of the complete operation was 0.094 second.

The advantages of this process are as follows: At least three-fourths of the power consumption is saved as compared with butt welding; the speed of the process is very great and thus production depends almost entirely on the time required to handle the pieces; unusual welds may be accomplished, such as welding of small rods to heavy plates or blocks, without previous treatment or preparation of the surface; the energy is consumed in a very small amount of material and does not heat up the rest of the stock, and it may therefore be used where excessive temperatures of the whole stock would cause a loss of temper; unlike metals may be welded as readily as metals of like kind; the character of the welds realized after a proper adjustment of the apparatus is made is independent of the skill of the operator, thereby reducing labor cost, and the percussive process produces a much smaller fin or flash than butt-welding. The reduced fin results in a decreased cost for finishing the parts.—*Electrical World.*

Electrification of the Paulista Railway

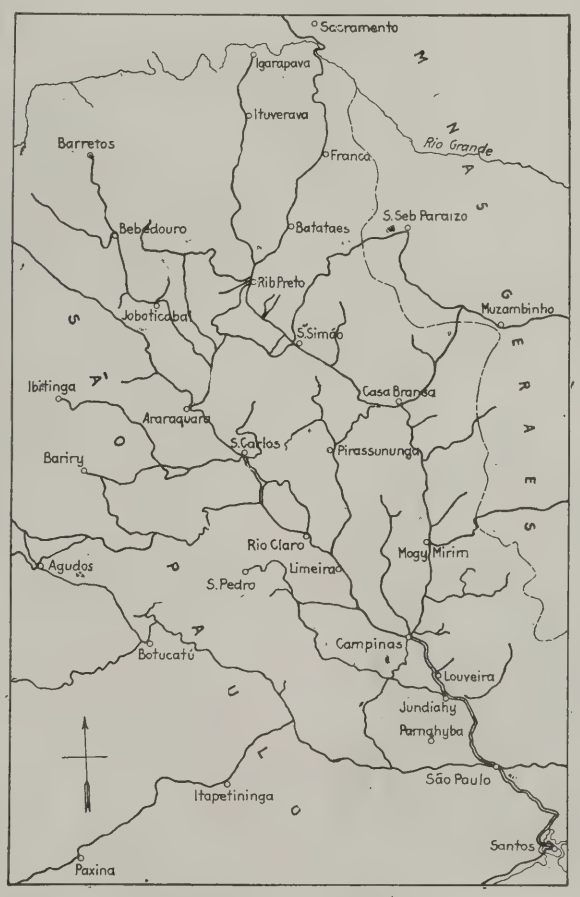
Fuel Scarcity Forces the Adoption of Electric Motive Power on Brazilian Wide Gage Line

By W. D. Bearce
Railway and Traction Engineering Dept. General Electric Co.

THE concluding shipments are being made on the $2,000,000 contract with the International General Electric Company for the electrification of a section of the Paulista Railway in Brazil. This project includes a double track section 28 miles in length between Jundiahy and Campinas.

The motive power equipment consists of eight freight locomotives weighing 100 tons each and four passenger locomotives weighing 120 tons each. Work has been progressing on these locomotives for about a year at the Erie works and the first locomotive was put on the test track about the middle of March. Complete running tests were made and two freight locomotives were shipped before the middle of May. One of the passenger locomotives was also put on the test track and shipment was made, according to schedule, during May.

In addition to the locomotives, the contract included the equipment of a complete 3,000-volt direct current substation of 4,500 kw. capacity consisting of three 1,500 kw. 3 unit motor generator sets, transformers, switches and high tension equipment. Overhead line material has also been furnished for 76 miles of track and material for 10 miles of 88,000 volt, 3 phase, 60 cycle high tension transmission in duplicate from the lines of the Sao Paulo Light & Power Co.



Paulista Railway System and Connections

The line from Campinas to Jundiahy is a main line section connecting at the southern terminus with the Sao Paulo Railway and the Central Railway of Brazil. The Central Railway is government owned and electrification of this line has also been authorized. At Campinas and other points north connection is made by the Paulista Railway with a number of feeder lines, which bring large quantities of coffee and other raw material from the interior.

The road bed is rock ballasted and the construction throughout is equal to any of the main line roads in the United States. The track gage is 5 ft. 3 in. on the section to be electrified, but some of the connecting lines are narrow gage and facilities are provided for transferring the car bodies complete with merchandise to narrow gage tracks and vice versa. The passenger service includes high speed passenger trains with full Pullman accommodations. The present locomotive equipment consists of heavy type locomotives for freight service with high speed engines for passenger service. All are equipped for burning wood as fuel instead of coal. On account of the high price of coal and the great difficulty in securing it, wood is burned almost exclusively in this part of South America. The variety most used is known as quebracho, which gives satisfactory results except that, of course, the quantity required for a 100-mile run is very bulky. Recently there has been difficulty in procuring even wood that is suitable for this work. Electrification, therefore, was decided upon as the remedy.

The section selected for electrification presents a rather difficult profile, including maximum grades of 1.5 to 1.8 per cent. While the immediate plans of the Paulista company contemplate electrification for only a distance of 73 miles, the design and capacity of all apparatus and equipment is suitable for operating on an extension to Sao Carlos, a total distance of 129 miles. The approximate tonnage handled over this line during the year 1918 from Jundiahy to Cordeiro was about 275,000,000 ton-miles, including freight, passenger and non-revenue service. The electrical equipment is designed for handling approximately double this amount and the sub-station and line equipment is also capable of handling approximately double the 1918 revenue tonnage. As a basis for estimates it was assumed that the number of trains per day over the initial electric zone will be six-passenger and twenty-one freight in each direction, making a total of fifty-four trains per day.

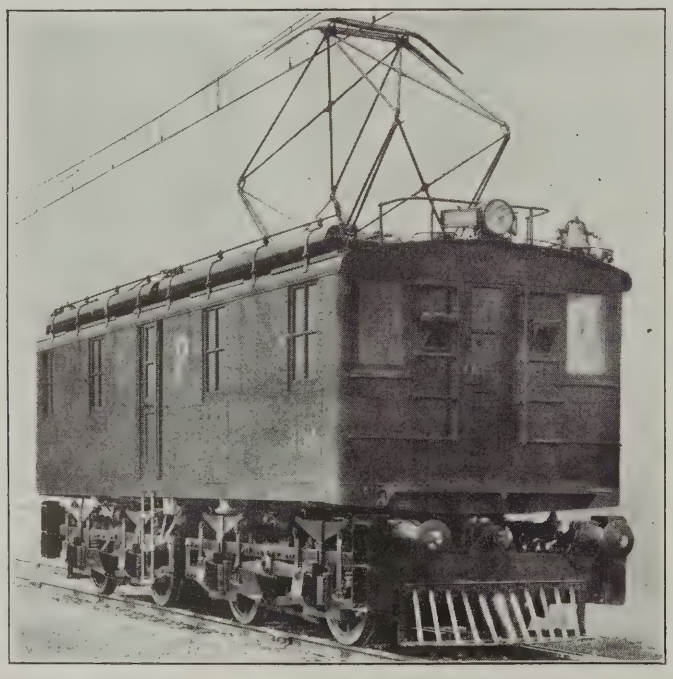
Locomotives

The initial order for locomotives included eight freight and four passenger, all of the twin geared type. These are similar to those in successful use in United States on the Chicago, Milwaukee & St. Paul Railway, the Butte, Anaconda & Pacific Railway, the Detroit River Tunnel

and other roads, and include the well tried features of the best types of locomotives now in service.

Freight Locomotives.—The freight locomotives weigh 100 tons, all weight on driving axles. They are designed for handling a trailing train of 770 tons on the maximum 1.8 per cent grade at speeds of from 12 to 16 miles per hour. The maximum allowable speed on tangent level track is 30 to 35 miles per hour. It is expected that because of the greater capacity and higher speed characteristics the electric locomotives will provide an appreciable improvement in the existing steam service, both as regards schedule speed and weight of trains handled.

As shown in the photograph the freight locomotive has a running gear consisting of two 2-axle trucks coupled together by an articulated joint, and a single cab of the box type. The draft gear is mounted on the trucks and, all hauling and buffing stresses are transmitted through the truck frames and articulated joint, thus eliminating any possibility of damage to the cab and platform structure. Each truck is equipped with two GE-267 motors of the box frame type geared to the driving axle by two sets of gearing, one at each end of the motor. One of the trucks is side equalized and the other cross equalized, thus providing the equivalent of a three point support for the super-structure. The diameter of the driving wheels



Freight Locomotive for the Paulista Railway

is 42 inches and of the cast wheel center 36 in. allowing for a steel tire 3 in. in thickness. The overall length of the locomotive is 39 ft. 2 in. and the rigid wheel base 8 ft. 8 in. The interior of the cab is divided into three compartments by partitions or bulk heads so placed as to form two end compartments about 5 ft. in length for the operator's cabs and the remainder for housing the control equipment, compressor-exhauster set and other auxiliary apparatus. Two pantograph trolleys are of the double pan sliding type similar to that used on other heavy electrification projects and are mounted on the cab roof. These are insulated for 3,000 volts and are designed to operate through a range of from 15 to 22 ft. above the rail.

To conform to the equipment on this road it is necessary to provide control for the vacuum type brakes used on the cars. Two entirely different systems of brakes are therefore provided for; a straight air brake system for the locomotive, and vacuum type brakes on the train. The two systems are manipulated in the same manner as the usual all compressed air type, the locomotive brakes being applied automatically at the same time as the train brakes under normal running. Brakes can be applied on the locomotive alone or on the train alone if desired. When regenerating, however, there is a magnet valve so arranged that straight air cannot be applied while returning power to the trolley. However, should an emergency application be made, regeneration is discontinued and the brakes are applied on the locomotive.

Motors.—The motors are of the box frame commutat-

120-Ton 3,000-Volt Passenger Locomotive

ing pole type designed for self ventilation. This feature is made possible by the fact of the increased room due to the wide gage. In order to supply clean air for ventilation of the motors, a ventilating pipe is provided, reaching to the outside of the locomotive truck. The fan is of the multiple type made integral with the armature head flange on the end opposite the commutator. Air is taken into the frame at the commutator end through a screened opening and divides into two streams, one passing over and around the armature and field coils, while the other is drawn through longitudinal ducts in the armature core. All of the air is expelled from the frame at the end opposite the commutator. These motors are designed for operation at 1,500 volts per commutator with two motors connected permanently in series for the 3,000 volt supply. The gears are of the forged steel type with a reduction of 82 to 18 or 4.56.

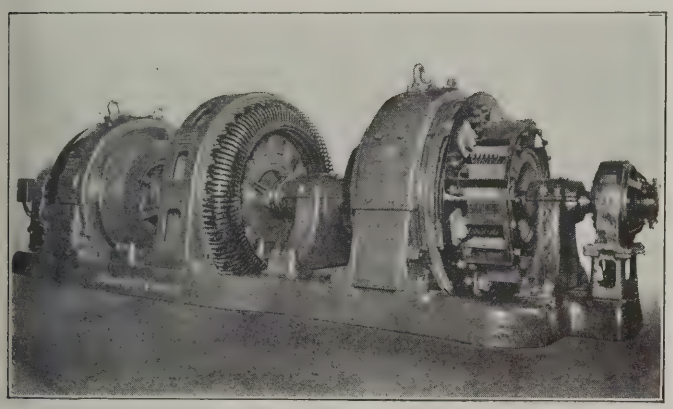
Control.—Control equipment is the type M designed for non-automomatic single unit operation of the locomotives. All contactors, rheostats, transfer switches and the reverser are located in the central compartment of the cab. The master controllers, brake control, sander control, pantograph and other control devices are in the operator's cabs at the ends of the locomotive.

Energy for operation of the control is obtained from a 65 volt generator which is a part of the compressor exhauster unit. A 65 volt storage battery is connected in parallel with the generator to maintain constant voltage and to supply auxiliary lighting when the set is not running.

The motors may be operated all four in series through 14 steps of resistance, and with two motors in series and two groups in parallel through 10 steps of resistance. Regenerative braking is provided for returning energy

to the line on descending grades. Ten steps are used for the regenerative braking control. The lighting and miscellaneous equipment includes the necessary lamps, switches, fuses and wiring for illuminating the cab and for headlights and accessories. The headlights are of the incandescent type with side number-plates and are supplied from the 65 volt generator or battery. Speed recorders are included as a part of locomotive equipment. The draft gear is attached to the end frames of the trucks and is of the usual European type. The compressor-exhauster set is a combined unit having a compressor with a total piston displacement of 48 cu. ft. of air per minute at a pressure of 90 lb. per sq. in., an exhauster with a displacement of 150 cu. ft. of air per minute and a 65 volt direct current generator above mentioned. The unit is driven by a 3,000 volt direct current motor operating from the trolley circuit.

Passenger Locomotives.—The passenger locomotives are similar in design to the freight units except that a two axle guiding truck is provided at each end to comply with the railway company's specifications for high speed service. The motors used are identical to those on the freight locomotive except for the change in gear ratio to provide for maximum speeds of from 56 to 62 miles



Three Unit Four Bearing 1,500 Kw. 3,000-volt d. c. Motor Generator Set for the Paulista Railway

per hour. The running gear consists of two 2-axle driving trucks the inner ends of which are connected by an articulated joint. The outer ends are extended and supported on the guiding trucks by roller centering devices over the front axle and an articulate joint over the rear axle which also connects the guiding and motor trucks. The general arrangement of motors and control is the same as that on the freight locomotives, and a similar system of regenerative braking is also provided. This locomotive is designed for hauling a train of 440 tons trailing up a one per cent grade at a speed of 38.8 miles per hour. The gear ratio on the passenger locomotive is 70 to 30 or 2.33.

For speeds above the full series and full parallel connections a shunted field connection is provided by means of which the field current is reduced for maximum speed running.

Regenerative braking is accomplished by connecting one motor in such a way that it excites the field of three other motors and also its own field. This scheme is in general similar to that used on the Chicago, Milwaukee & St. Paul gearless passenger locomotives and eliminates the necessity for a separate motor generator set for excitation. A balancing resistance is connected in the circuit to protect the motors against sudden surges of the line voltage and to give effective protection against line voltage changes. In order to begin regeneration, the main controller handle is turned to the first notch series position and the selective handle to the braking position. The main handle is then notched up until the desired braking effect is obtained.

A high speed circuit breaker is placed between the 3,000 volt trolley and the locomotive apparatus. The duty of this breaker is to protect the motors and equipment from any injury due to short circuits or overloads. In case of a short circuit this breaker cuts in a protective resistance and then opens the line contactor. The action is very rapid so that in case of heavy overload, or short circuit, the possibility of damage is reduced to minimum. Breakers of a similar type are in operation in many parts of the United States both on locomotives and in substations.

The following table gives the dimension, capacity and weights of the two locomotives:

Data on Electric Locomotives for Paulista Railway

	Freight	Passenger
Length overall	39 ft. 2 in.	55 ft.
Width	10 ft. 1¼ in.	10 ft. 1¼ in.
Height over trolley down	14 ft. 3 in.	14 ft. 3 in.
Total wheel base	26 ft. 8 in.	46 ft. 0 in.
Rigid wheel base	8 ft. 8 in.	7 ft. 9 in.
Total weight	200,000 lb.	240,000 lb.
Weight on drivers	200,000 lb.	160,000 lb.
Weight per driving axle	50,000 lb.	40,000 lb.
Weight per guiding axle	None	20,000 lb.
Weight of mechanical equip	115,400 lb.	155,400 lb.
Weight of electrical equip	84,600 lb.	84,600 lb.
Diameter of drivers	42 in.	42 in.
Diameter of guiding wheel	.....	36 in.
Number motors	4	4
Gear ratio	82/18	70/30
Total continuous rating hp	1,600	1,600
Total (1 hour rating) hp	1,680	1,680
Tractive effort cont	28,820 lb.	14,720 lb.
Tractive effort 1 hr	30,600 lb.	15,680 lb.
Speed continuous rating m.p.h	21 (34. km.)	41.25 (66.4 km.)
Speed 1 hour rating m.p.h	20.8 (33.5 km.)	40.5 (65 km.)
Maximum safe speed	28 (45 km.)	53. (85 km.)
Tractive effort 30% coef. adh	60,000 lb.	48,000 lb.

Substations

For the initial electric zone between Jundiahy and Campinas, one substation is being installed located at Louveira a distance of 9.5 miles from Jundiahy. This station contains three 1,500 kw. 3 unit synchronous motor generator sets each arranged to operate its two generators in series for 3,000 volts. Power is received from an 88,000 volt 60 cycle transmission line and stepped down through three 3 phase, 1,900 kva. transformers to 2,300 volts for the synchronous motor.

Transformers.—The three phase oil insulated and oil cooled transformers which step the voltage down to 2,300 are rated at 1,900 kva. The tanks are of steel plate with all joints welded. Four separable steel radiators are mounted on the outside of the tank to provide sufficient radiating surface.

Each transformer is provided with an oil conservator or auxiliary tank mounted on the cover. This device permits the main tank to be completely filled with oil, and differences in volume of oil due to temperature changes take place entirely within the conservator. This arrangement prevents the condensation of any moisture within the transformer and such condensation as may occur in the conservator is collected in a sump, is indicated on a gage glass and may readily be drawn off through a pet cock. Since there is no air in the main tank above the oil there is no possibility of explosion due to ignition of gases formed from hot oil. The guaran-

teed efficiency of these units at normal load is 98.3 per cent.

Four 2½ per cent taps are provided in the low voltage winding to compensate for variation in the transmission line voltage and 50 per cent starting taps are also provided for starting the motor generator sets.

Motor Generators.—The motor generator sets are especially adapted to handling heavy railroad service and are substantially similar to those furnished for heavy electric railroad work in the United States. The generators are designed for 1,500 volts per commutator and are permanently connected in series for 3,000 volt operation. They are separately excited from a 125 volt direct current exciter mounted at one end of the set. The series field is designed to provide flat compounding from no load to 150 per cent load. They are equipped with commutating poles and compensated pole face windings to insure sparkless commutation at all loads. A load of three times normal rating can be carried for five minutes without injury. Under tests made before shipment loads of from five to six times normal were carried without sparking. All of the fields of both generators are connected to the low side to reduce the possibility of injury from high voltage. A simple form of flash barrier is provided for the commutators similar to that supplied on other high voltage direct current machines.

The synchronous motor is excited from a second 125 volt exciter direct connected to the opposite end of the set. This exciter carries a compound winding excited from the main 3,000 volt conductor so that the motor field excitation varies in proportion to the load on the set. This provides for the proper excitation to give correct power factor with varying loads and also insures stable operation under heavy overloads. The equipment is designed for the inverted operation control current, of regeneration.

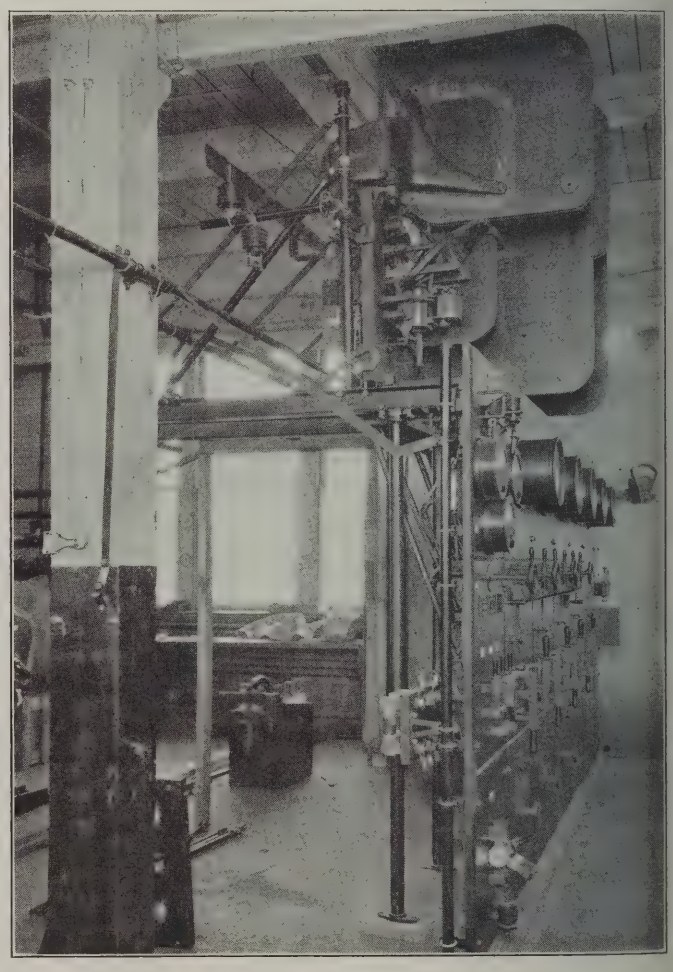
The switchboard is similar in design to other 3,000 volt d. c. equipment. The 3,000 volt panels are installed together with the auxiliary station lighting panel. The high voltage panels include one for each of the motor generator sets, and one for each outgoing feeder. The main circuit breakers are located above and to the rear of the switchboard panels so as to be well out of reach to prevent accidental contact. They are remotely controlled from operating levers located on the front of the panels. A 3,000 volt line switch is also included with each circuit breaker. These switches are remote controlled from the front of the panel, as a safety measure. The switch handles for the circuit breakers are inverted to distinguish them from the line switches. The alternating current switchboard is electrically controlled throughout. For lightning protection a 96,000 volt aluminum cell arrester is installed in the high tension room of the station.

As a protection from short circuits and excessive overloads a high speed circuit breaker is installed with each motor generator set. This is connected to the negative terminal of the machine and arranged to connect a limiting resistance into the circuit upon opening. At the same time the station circuit breakers are opened completely cutting off the power supply. The speed of these circuit breakers is such that resistance inserted in the circuit before the short circuit current reaches sufficient value to injure the apparatus.

Other auxiliary equipment supplied to the station includes a 15 ton hand operated crane, a portable oil filter press and oil testing equipment, and a stationary compressor set. For control current a 4¾ kw. battery charging motor generator set is used with a 170-volt storage battery.

Power Lines

The railway company's high tension transmission line has been constructed with duplicate circuits mounted on separate wood poles between Jundiahy and Louveira a total distance of 10 miles. At Jundiahy this line is permanently tied in with a new line constructed by the Sao Paulo Light & Power Co. extending a distance of about 17 miles to the hydro-electric station at

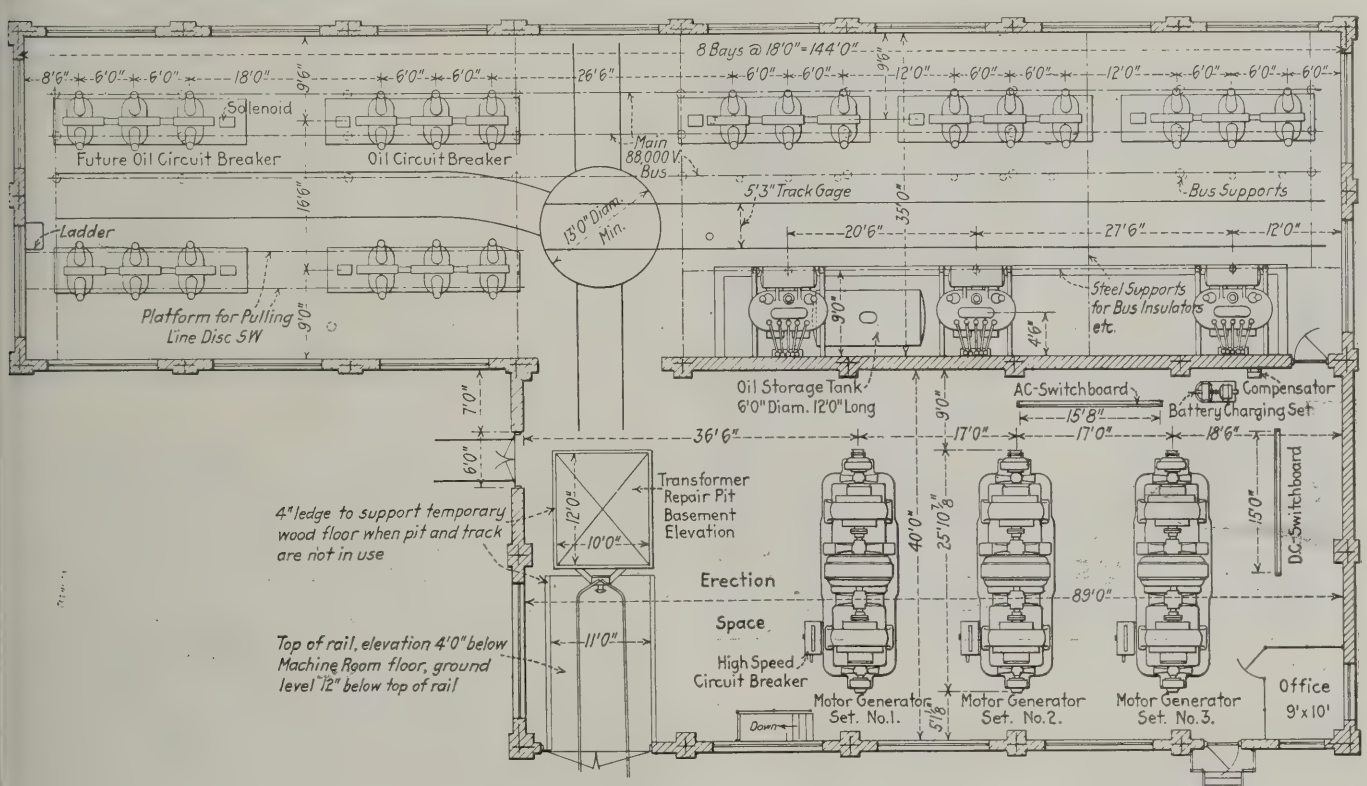


3,000-volt d. c. Generator and Feeder Railway Switchboard

Parnahyba. The power company's line is constructed with an **H** type pole line carrying the duplicate circuits. This transmission line from the water power plant to the substation will thus be operated over a distance of 27 miles, as a single system at 88,000 volts 3 phase 60 cycle. The line is designed for ultimately supplying three substations and the conductors are of 1/0 B&S stranded copper which will insure a very low line loss under ordinary operating conditions. On the railway company's line two cross arms are used with large pin type insulators. A ground wire is also carried on each transmission line for lightning protection.

Secondary Distribution.—The overhead line construction is of the same general design as that used on the

Chicago, Milwaukee & St. Paul Railway. This is known as the twin catenary construction having two 4/0 trolley wires supported from the same steel messenger by loop hangers. Wood poles suitably guyed are used for supporting the catenary. The hangers for the two contact wires are attached at alternate points giving a most flexible type of construction and insuring the elimination of all "hard spots." Bracket supports are used on single track construction and cross span for muitiple track work. The normal height of the contact wire is 21 ft. above the rail. For all sidings and yard tracks a single wire is used over each track. The material furnished by the General Electric Co. includes hangers, pull offs, copper and steel wire, miscellaneous hardware, etc., for 76 miles of track. The use of the twin catenary construction is particularly successful for lines operating heavy trains requiring the collection of large amounts of current through pantograph trolleys. In addition to the advantage of the two contact wires for handling the current required, this construction also insures practically sparkless commutation at the point of contact, both for heavy freight and high speed passenger operation.


8 Bays @ 18'0" = 144'0"
Solenoid
Future Oil Circuit Breaker
Oil Circuit Breaker
Main 88,000 V. Bus
5'3" Track Gage
Bus Supports
Ladder
13'0" Diam. Min.
Platform for Pulling Line Disc SW
Steel Supports for Bus Insulators etc.
Oil Storage Tank 6'0" Diam. 12'0" Long
AC-Switchboard
Compensator
Battery Charging Set
Transformer Repair Pit Basement Elevation
4" ledge to support temporary wood floor when pit and track are not in use
Erection Space
Top of rail, elevation 4'0" below Machine Room floor, ground level 12" below top of rail
High Speed Circuit Breaker
Motor Generator Set. No.1.
Motor Generator Set. No.2.
Motor Generator Set. No.3.
DC-Switchboard
Office 9'x10'
Down

Arrangement of Apparatus at the Louveira Substation on the Paulista Railway. Power is Received at 88,000 Volts—3 Phase—60 Cycle and Changed to 3000 Volt D. C. by Three 1500-Kw. Motor Generator Sets

Bonding

The weight of rails on this line is 91 lb. and these are bonded with the pin terminal type bond 42" in length and 211,600 circular miles cross section. Cross bonds are also used for interconnecting the rails of the same track and for bonding between tracks on the multiple track sections.

Locomotive Testing and Shipment

In the preparation of the electric locomotives for testing and for export shipment there are a number of unusual features which may be of interest. The gage of track on the Paulista Railway being 5 ft. 3 in. special arrangements were necessary to provide for removing the locomotives from the shop to the test track. To provide the necessary test-track about one mile of extra rail was laid on the East Erie Commercial Railroad with 5 ft. 3 in. gage. In order to transport the locomotives from the shops to the test track a distance of about three-quarters of a mile, special transfer trucks were used; one for each truck of the locomotive. By means of these trucks, which operate on their own wheels of standard gage the locomotives were moved out over the usual transfer table and standard gage track to the special gage section provided for testing. Upon reaching this section they were moved off the transfer trucks over a ramp, the end of which was elevated to the same height as the special trucks.

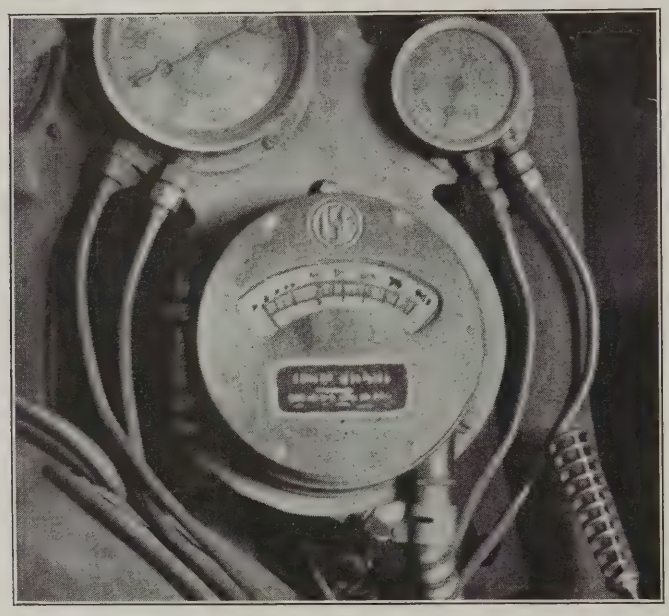
A complete set of tests were run on all locomotives including regenerative braking and high speed running. After test the locomotives were transferred to the shipping department where they were disassembled and prepared for export shipment. The cab complete was removed from the truck and the pantograph, bells, etc., removed from the cab roof. Each truck was shipped separately without removing the motors from the truck frame. In the case of the passenger locomotive, each bogie truck was shipped with the adjacent motor truck without disassembling. On account of the large vessels available for making this shipment it was not necessary to reduce the locomotive to small packages.

Progress on the construction is shown by the fact that the first freight locomotive was ready for test March 15; during the month of May three freight and one passenger locomotives were shipped and progress on the balance of the order indicates that similar shipments will be made the following two months in accordance with the terms of the contract.

Pyrometers Promote Locomotive Efficiency.

As a positive check on the efficiency of superheater locomotive performance, pyrometers have demonstrated their great value. They register steam temperatures at all times, and enable engine crews to keep a constant check on the fire, water level, draft conditions and locomotive performance generally. A locomotive cannot be operated without a steam gage. Why should it operate without a temperature gage, since its efficiency is dependent upon the degree of superheat attained?

To illustrate the importance of pyrometers, a hypothetical case is assumed of a locomotive operating without one and hauling a specified train load on a regular run. Suppose that the locomotive operates on the first trip all right as far as steaming and fuel consumption is concerned. A front end air leak may develop on the



Location of Pyrometer Indicator in Cab

second trip and easily pass overlooked for a day or two. Gradually the engine crew notices an excessive coal consumption, and finds difficulty in keeping up steam. As the leak becomes greater the flues get dirty, the fireman is finally unable to keep up steam pressure and the locomotive fails on the road.

When locomotives are equipped with pyrometers, however, troubles are apparent as soon as they develop, and can be corrected. Any defect which tends to decrease the gas temperature and resulting steam temperature is immediately reflected in the pyrometer. A low steam temperature warns the enginemen that something is wrong and when this is reported at the end of the trip, the roundhouse force can locate and correct the trouble before the locomotive goes on the road again.

It is important that engine crews be instructed as to the purpose of pyrometers and this instruction should require but a short time since they already know that the efficiency of a superheater locomotive depends upon the amount of superheat attained. A crew, trained to operate a locomotive equipped with a pyrometer, can check its operation and know when it is working at highest efficiency. Defects in operation, being made apparent by a low steam temperature reading, can be quickly corrected, and with a little practice, avoided. The net result is a saving in fuel and more efficient locomotive operation.

Defects Shown by Low Pyrometer Readings

Where pyrometers are being used, many enginemen depend more completely upon their indications than upon the steam gages. When a locomotive is working under average conditions, and a perceptible drop in steam temperature is noted, some of the following defects either in the operation or the condition of the locomotive may be looked for.

First—The water level in the boiler may be too high, causing priming. The superheater then has to evaporate the water in the steam and consequently the final temperature of the steam is reduced.

Second—The fire may not be in a proper condition, due to too heavy or too light firing. Either condition will reduce the firebox temperature and consequently the final temperature of the steam.

Third—A portion, or all, of the large boiler flues may be stopped up.

Fourth—Air or steam leaks may be present in the front end, a condition which seriously affects the draft.

Fifth—The damper may not operate properly and interfere with the passage of gases through the flues.

Any one or any combination of these defects will cause a reduction in steam temperature which is immediately indicated by the pyrometer.

View Showing Steam Fixture in Steam Pipe and Connection to Cab Through Handrail

The first two of these conditions can be prevented or corrected by the enginemen; the last three should be reported for attention at the terminal. Prompt attention to these conditions will save hundreds of thousands of dollars for the railroads, not only in fuel, but in eliminating delays and preventing minor repairs from becoming costly. Advantages resulting from the use of pyrometers would seem to warrant the general application of these instruments to all superheated locomotives.

THE INTERCHANGE

A Substitute for a Three-Way Switch

Three and four-way switches are used in some cars for controlling the lights. Fig. 1 shows a diagram of connections used in certain baggage cars which have three-way switches, one located at either end of the car and a four-way switch near the side door. It is quite possible to use four-way switches in place of three-way switches by connecting them as shown in the diagram in Fig. 2.

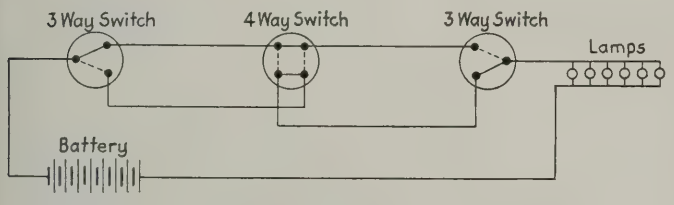


Fig. 1—Three Point Control Using Two 3-Way Switches and One 4-Way Switch

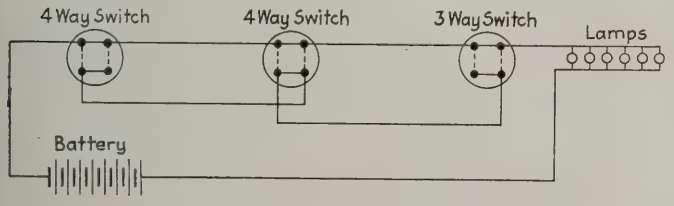


Fig. 2—Three Point Control Using 4-Way Switches in Place of 3-Way Switches

This knowledge should be of value to the car lighting maintenance man as the stock of switches is usually irregular, and when the supply of three-way switches is exhausted, a four-way switch may be substituted.

Is This Luck?

He worked by day
  And toiled by night,
He gave up play
  And all delight.
Dry books he read
  New things to learn
And forged ahead
  Success to earn.
He plodded on
  With faith and pluck,
And when he won
  Men called it luck.

Promotion

Promotion comes to him who sticks
Unto his work and never kicks,
Who watches neither clock or sun,
To tell him when his task is done,
Who toils not by a stated chart,
Defining to a job his part,
But gladly does a little more
Than he's remunerated for.
The man in factory, company or shop
Who rises quickly to the top
Is he who gives what can't be bought
Intelligent and careful thought.

No one can say just where begins
The service that promotion wins
Or when its ends 'tis not defined
By certain hours or any kind
Of systems that have been devised,
Merit cannot be systemized;
It is at work when it's at play,
It serves each minute of the day,
'Tis always at its post, to see
New ways of help and use to be.
Merit from duty never shrinks,
Its cardinal virtue is—it thinks!

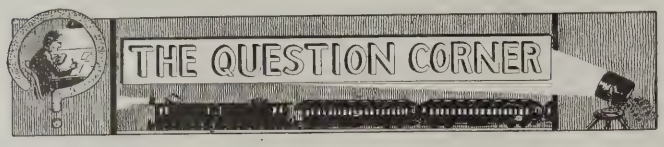
Promotion comes to him who tries
Not solely for a selfish price,
But day by day and year by year
Holds his employer's interest dear,
Who measures not by what he earns
The sum of labor he returns;
Nor counts his day of toiling through
Till he's done all that he can do.
His strength is not of muscle bred,
But of the heart and of the head
The man who the top attains
Must demonstrate that he has brains.

The Short Cut

An ambitious young man went to a university professor and said: "Sir, I desire a course of training which will fit me to become the superintendent of a great railway system. How much will such a course cost, and how long will it take?"

"Young man," replied the professor, "such a course would cost you $20,000 and require twenty years of your

time. But, on the other hand, by spending $300 of your money and three months of your time you may be elected to Congress. Once there you will feel yourself competent to direct not one but all the great railroad systems of our country."—*Santa Fe Magazine.*



Answers to Last Month's Questions

1. Is there any explanation for the magnetic storm in the Aurora Borealis which upset so many communication lines on May 16?

2. If you have two steel bars of exactly the same size and appearance and only one of them is magnetized, how is it possible to determine which is the magnetized bar, keeping in mind that nothing but the two bars are to be used for testing?

3. When the battery on a car shows abnormally low voltage, is it better to test for dead cells before or after it has been charged?

4. Can you give me any information regarding the reconnecting of a 220 volt, 2 phase, 4 wire, 60 cycle induction motor so that I may use it on 440 volts of the same frequency?

* * *

I believe the following to be the correct answers to the June questions:

1. This was caused by sun spots.

2. If A. G. R. means permanent bar magnets, such as are used on a magneto, they can be tested in the following manner: referring to Fig. 1, if *A* is the magnetized bar it will attract bar *B*, and if *B* is the magnetized bar, *A* will not be attracted, for midway between the

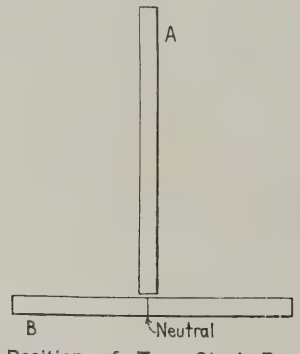


Fig. 1.—Relative Position of Two Steel Bars in Testing For Magnetism

north and south poles there is a neutral point at which very little magnetism is manifested.

3. The best way to test a very low battery is to first test before charging (with full load on) mark the low cells and then test again after charging. If there are only a few cells very low, it is better to charge them apart from the normal cells.—A. H. M.

* * *

1. Of the numerous theories which have been advanced from time to time regarding the Aurora Borealis or Northern Lights, and their apparent connection with so-called magnetic storms, the most generally accepted theory is the one advanced by a Swedish physical chemist, by the name of Arrhenius. He believes that under certain conditions of unusual activity, the sun discharges electrical particles or ions which are drawn toward the magnetic poles of the earth. When these ions reach the upper layers of air(they give up their electrical energy and the result is an electrical discharge through rarefied air. This discharge produces an effect very similar to that seen in a glass tube from which the air has partially been exhausted when an electric current of high potential is introduced into the tube by two platinum electrodes at either end. Although the cause of the Aurora Borealis has never been positively determined, it is believed that it is due to an electrical discharge which takes place in the rarefied atmosphere about 50 miles above the surface of the earth, this discharge producing the characteristic illumination. It has been observed on many occasions that unusually brilliant Aurora displays take place at times when the greatest number of spots make their appearance on the face of the sun. It is believed that these sun spots indicate that some violent disturbance is taking place on the sun and that this disturbance is responsible for the unusual electrical conditions which result in the more brilliant Aurora display as well as the magnetic storms which frequently accompany it.

Magnetic storms such as occurred on May 15 and 16, seem to coincide with the appearance of a large number of sun spots. The data obtained as a result of many observations tend to indicate that these magnetic storms and consequent disarrangement of communication lines is in some way related to the number of sun spots and their periodical appearance. It is, of course, difficult, if not impossible, to prove definitely whether or not such is really the case.

2. Two steel bars, one of which is magnetized, and the other non-magnetized, may be distinguished from each other without the aid of any other material by a very simple and conclusive test. Place one of the bars upon a table and hold the other in the hand so that one of the ends touches the middle of the bar at rest. If the horizontal bar is attracted by the end of the vertical bar then the vertical bar is the magnet.

3. A test should be made for dead cells when the battery voltage is low, which is when the car is first received. If an attempt to locate these cells is made after the battery has been fully charged, it will probably be found that every cell shows top voltage unless there is a severe short circuit somewhere between the plates.

* * *

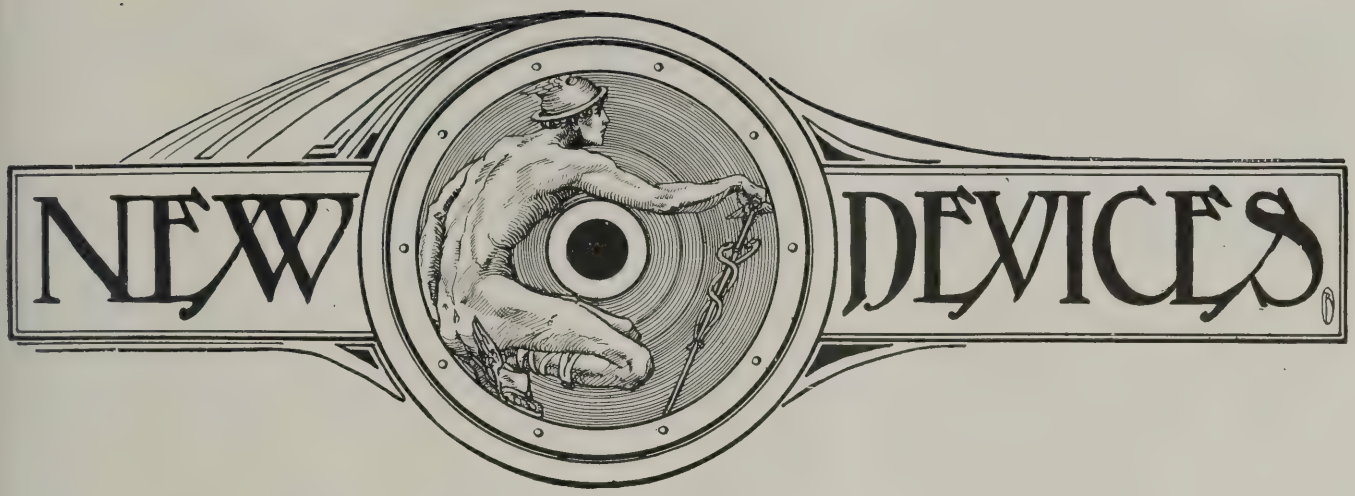
The answer to question 4 does not appear in this issue, probably for the reason that the question itself did not give quite sufficient information regarding the particular type of motor under consideration. Additional data have been secured to the effect that the motor in question was of the squirrel cage type. Its revolutions per minute at full load are 900, and the stator has 48 coils connected in parallel. We are expecting to give a complete answer to this question in the next issue.

* * *

Questions for July

1. Give some reliable test that will show whether or not electrolyte contains iron.

2. In what percentage of iron in electrolyte would you consider injurious enough to prohibit the use of the electrolyte again?—R. Y.



Outlet Box for Reinforced Concrete Construction

To meet the special needs of reinforced concrete work, the Adapti Company, Cleveland, Ohio, has brought out a new stamped steel, octagon outlet box. The octagon shape offers a flat surface for lock nuts and bushings, thus making a tighter and better fit than hat obtainable with round surface outlet boxes. The back is removable and is held in place by screws. A projecting lip is tapped to take these screws and this also serves the purpose of closing the key-hole slots against leaking concrete. The box is nailed to the forms through projecting ears which are held in place by cover screws. It is not necessary to follow the usual practice of trimming the nails after the forms are taken down, as this box leaves both the nails and projecting ears exposed and they are easily removed by loosening the cover screws. When an extra deep box is required, two or more boxes can be used to make one deep unit. The box is made for ½, ¾ and 1 in. knockouts, in any combination of outlets.

Outlet Box With Part Cut Away

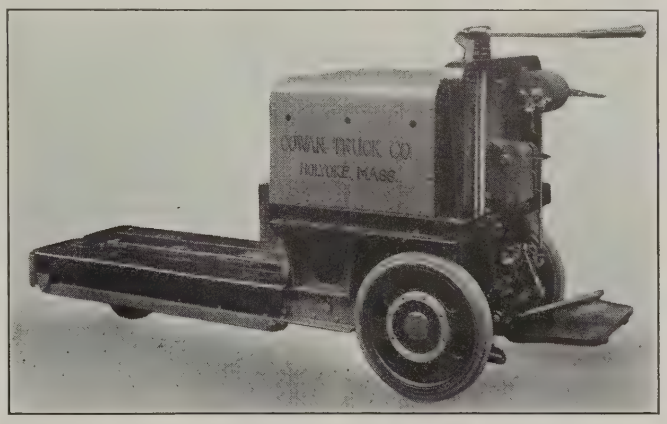
Improved Electric Self-Loading Truck

Several distinctive features have been included in the recently improved truck illustrated, which is made by the Cowan Truck Company, Holyoke, Mass. Simplicity of design is combined with a minimum of parts all sturdily constructed. The guaranteed capacity of the truck is 5,000 lb.

The lifting mechanism is of the heavy bell crank type, a new application to electric truck lifting mechanism construction. It is actuated by an independent, heavy duty, series wound motor with a worm gear reduction, the platform elevating vertically with a maximum rise of 4½ in.

The truck, equipped with a full capacity battery, elevates a 5,000 lb. load in five seconds, and elevates without load in three seconds. The full lowering time is three seconds. The platform may be stopped at any point going up or down and the direction of motion reversed.

An "anti-kick" device takes all jar from the steering handle when the truck travels over rough spots. The power axle consists of only three parts, a shaft, splined ball and clutch. The rear end is equipped with a heavy bumper which effectually takes all shocks and protects the rear end of the lift platform. It is also equipped with a draw bar attachment, permitting the truck to be used as a light duty tractor. The draw bar attachment is integral with the frame and, with a load on platform, there is no strain on the elevating mechanism.



Cowan Electric Self-Loading Truck

Other important features include an automatic brake and circuit breaker application, four wheel steer, single reduction worm drive of the power axle and easy accessibility of batteries, lifting and driving motors and control mechanism. The batteries are assembled in one tray for quick removal and are supported by springs which relieve them from road shocks and vibrations under all conditions of load. The controller is of the drum type with three speeds forward and three reverse.

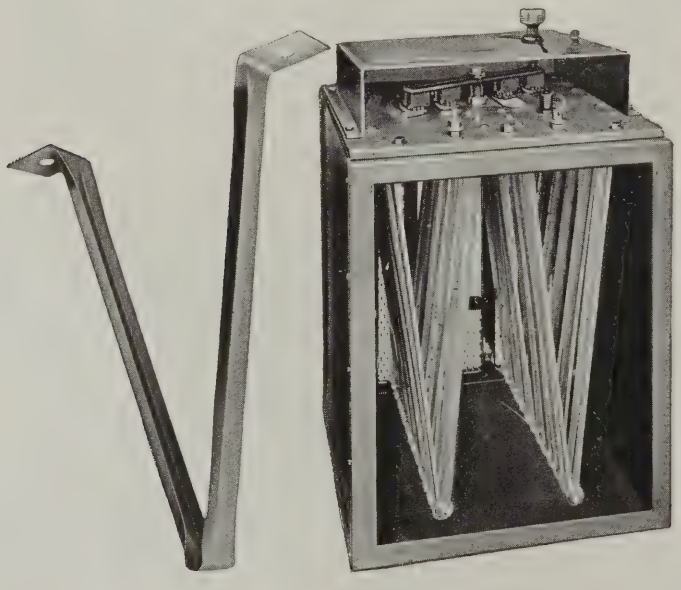
The turning radius (extreme outside point) is 7 ft. 10 in. By folding the foot pedal and steering handle into

a vertical position, the overall length is shortened for use on elevators. The length is 102 in. overall, or 91½ in. with the step raised. The width is 36 in. overall and 51 in. high over the steering shaft head. The truck will operate in intersecting aisles 58 in. wide. Further advantages of this truck are its all-steel construction, low center of gravity and ruggedness, features which are of particular value for the more or less severe usage accorded trucks in railroad service.

New Type of Resistance Unit

High current capacity rheostats which must dissipate comparatively large amounts of power are usually made with cast iron resistor units, cast in such form as to give a large radiating capacity. Cast iron has many disadvantages when used as a resistor. For instance, it is heavy, breaks easily, changes its resistance considerably with temperature, and disintegrates when subjected to repeated overheating. High resistivity alloys in ribbon form compared with cast iron have the advantage of light weight and are not easily broken. However, as ordinarily used, there is some difficulty in supporting ribbon resistors so that they will not sag and short circuit.

The Ward Leonard Electric Company of Mt. Vernon, N. Y., has recently developed a ribbon resistor unit, which is so designed as to utilize the strength of the



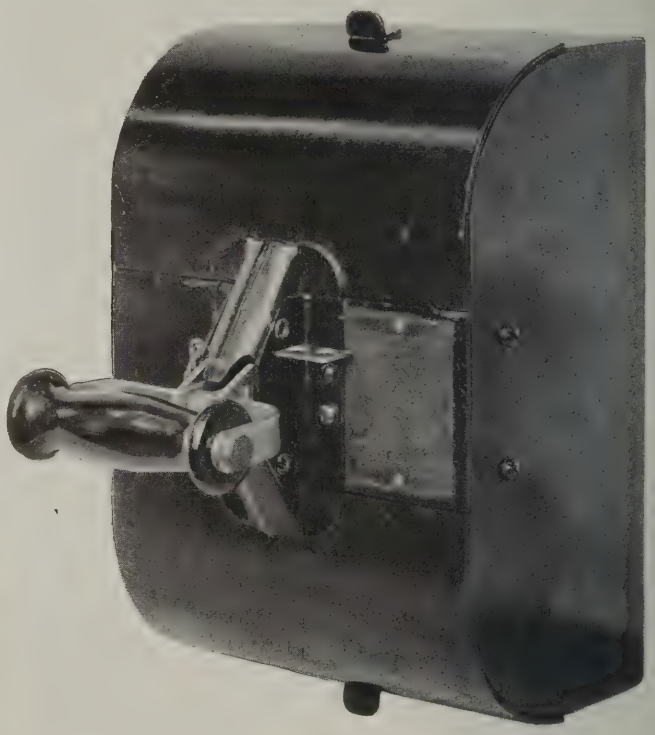
New Resistance Unit

material to such a degree that the complete unit is self-supporting. This unit is made by forming metallic ribbon into the trough or channel-shaped section which is flattened at both ends and in the middle. The unit is then bent about the middle to form a "V" as shown in the accompanying illustration.

The complete resistor is made up of a number of such units connected in series or parallel. When connecting in series the units are mounted in zigzag fashion, being joined at the feet where they are held in close contact by a bolt through the panel board. When they are used in parallel the connections are made by means of busbars which join the feet of the resistors so connected. This inverted V-shaped unit when firmly attached to the panel possesses extreme rigidity and is said to maintain its position independent of expansion and contraction, even when heated as under heavy load conditions.

Starting Switch for Small A-C Motor

An a-c motor starting switch for use in connection with small alternating current motors has recently been brought out by the General Electric Company. The device consists of a triple or four-pole, single-throw, quick-make and quick-break switch and two special receptacles with left-hand screw threads for the protective plugs, mounted on a base and totally enclosed in a sheet steel case. The operating handle projects through the front of the case. The switch can be furnished with or without barriers and it will be noted that the switch without barriers is limited for use with three-phase, 110 and 220-volt motors, while the switch with barriers should be used with three-phase, 440 and 550-volt motors, and with all two-phase motors.



Small A. C. Motor Starting Switch

When the operating handle is pulled out, the switch is closed, and when the handle is pushed in, the switch is opened.

Overload protection is obtained by two time-limit protective plugs. These plugs contain a stationary contact post with a heating coil and a fusible link which binds a spring contact arm to the stationary post. In case of an overload, the current passing through the heating coil heats the contact post sufficiently to melt the low fusing alloy, which holds the two parts of the fusible link together, thereby releasing the spring contact arm, which opens the motor circuit. By reason of the time lag in the heating coil, the momentary inrush starting current will not cause the plugs to open the circuit.

Each switch is provided with a locking plate arranged for two padlocks, thus permitting the switch to be locked independently by two individuals.

General News Section

The National Carbon Company, Inc., Cleveland, Ohio, announces a substantial reduction in the price of all standard types of Columbia dry batteries. All new prices were effective as of June 1, 1921.

For the four months ended April 30 the Niagara Falls Power Company and Canadian Niagara Power Company reported a combined net income, after taxes and charges, of $609,953. Operating income amounted to $1,152,764, and total income $1,257,151.

The Westinghouse Electric & Manufacturing Company has recently established a system of inter-plant wireless communication service for the transaction of company business between its factories located in various cities. The plants which are being equipped are those at Cleveland, East Pittsburgh, Springfield, Mass., and Newark, N. J.

The Bryant Electric Company, Bridgeport, Conn., announces the appointment of Hoyt Catlin as its advertising manager. For a number of years Mr. Catlin has been connected with the electrical industry and since January, 1919, he has held the position as sales engineer with the Bryant Electrical Company, in which capacity he has been active in developing and selling heater switches and other specialties.

The Electric Service Supplies Company, Philadelphia, Pa., will act as exclusive selling agent for the Peerless Equipment Company of Hanover, Pa., manufacturers of the Peerless armature repair machinery and Segur coil winding tools. Heretofore Peerless armature tools were manufactured by the Manley Manufacturing Company, York, Pa., and Segur coil winding tools were manufactured by the Electrical Manufacturers Equipment Company, Chicago.

The Adapti Company, Cleveland, Ohio, announces that it has purchased the property and building formerly occupied by the Cleveland Refrigerator Company, 72nd street and Oakwood avenue. The new factory makes available four times the manufacturing space which the company has at present and the adjacent vacant ground included in the purchase will permit of liberal future expansion. It is expected that operating will begin at the new plant after July 15.

The B. F. Goodrich Company of Akron, Ohio, has recently announced the organization of the International B. F. Goodrich Corporation. The new company, which has just been incorporated under the laws of New York with an authorized capital of $10,000,000, will represent the B. F. Goodrich Company in all foreign countries except Canada. It will take over the parent company's interests in factories located in France and Japan, as well as its selling subsidiaries in Great Britain, Italy, France, South Africa, Straits Settlements and Porto Rico, acquiring distributors in all foreign countries. All of the different products now being made by the company in the Akron factories, will come within the scope of the new company. The New York offices will be located at 1780 Broadway and the administrative and operating offices at Akron, Ohio.

The Western Electric Company announces ten changes in its organization. F. H. Leggett, formerly eastern district manager, has been appointed general manager of telephone distribution and J. B. Odell was promoted to telephone distributor at New York. L. M. Dunn was transferred to New York as manager of the supply distribution. E. A. Brehm was appointed manager of the distributing house, while R. W. Van Valkenburgh was promoted to manager of the supply distributing house in Philadelphia. H. P. Hess and L. A. Davies were transferred to Dallas, Tex. G. T. Marchmont was appointed manager at Richmond, Va., V. B. DeForest was promoted to manager of the Kansas City house, succeeding F. B. Uhrig, who was granted leave of absence.

A. I. E. E. Standards Submitted for Approval

The American Institute of Electrical Engineers has submitted its standards (1921) edition) to the American Engineering Standards Committee for approval as an American standard.

The standards are submitted in accordance with the special provision in the procedure of the committee under which important standards adopted or in process prior to 1920 may be approved without going through the regular process followed in new work. The standards submitted represent the latest revision of the A. I. E. E. standardization rules, revised during 1919 and 1920. The first edition of the rules was issued in 1899.

The American Engineering Standards Committee would be very glad to learn from those interested of the extent to which they make use of these specifications and to receive any other information regarding the specifications in meeting the needs of the industry.

Hydroelectric Plan Devised for New York

According to a recent statement by H. E. Machold, speaker of the New York Assembly, the plans for the development of hydroelectric work at Messina on the St. Lawrence River, are well under way and that the work on the project might be expected to begin this autumn. It is estimated that sufficient power can be generated to operate all transportation lines and factories, as well as lighting plants in the city of New York. "The big problem, and it is one of the greatest that has ever confronted a commission in this state, is now before us," said Speaker Machold. "In brief, it is whether the state shall adopt a fiscal policy with reference to the development of the water power whereby the maximum of revenue shall be directly derived from those who lease power

sites from the state, or whether the state shall permit private capital to exploit these power sites on terms to be fixed by the Public Service Commission so advantageous to the public generally using the power, as largely to develop the commerce of the state and yield the state an indirect return through increased assessed valuations flowing from the development of the water powers. The undeveloped water powers are along the barge canal, Niagara Falls and river, the St. Lawrence river at Messina near the Canadian border, and Portage Falls. Of course, there are many other prospects, but these are the big ones. The Niagara river and Portage Falls are capable of much greater development, and all of these phases of the subject are now with the commission. Governor Miller is much interested in the progress of our work. We hope to have our report ready by early fall."

Single Phase Lines in Sweden

The success of electric railways being operated with single-phase alternating current in Sweden has attracted the attention of American engineers. This is proved by a committee of American Engineers, conducted by Mr. Shepard, the representative of the Westinghouse Co., visiting the Riksgränsenbahn recently. Amongst American experts for electrical railways, Mr. Shepard is reckoned with those, who prefer alternating current for railway-service.

The inspection lasted for over a week, and Mr. Shepard spoke very highly of the single-phase equipment of the Riksgränsenbahn, not only owing to the thoroughness of the equipment, but also on account of the easy manner in which the system may be extended. Since special suction-transformers have been installed which lead the stray currents from the ground back to the rails, the disturbances of neighbouring telephone systems have been overcome in a most perfect manner.

This good opinion of the American engineers has to a very great extent been merited by the German industry, for the railway-line Kiruna—Riksgränsen has been constructed under the management and economic responsibility of the Siemens-Schuckertwerke. Only recently a number of additional 2—6+6—2 locomotives have been ordered for the Riksgränsenbahn from the Siemens-Schuckertwerke and the Allgemeine Elektrizitäts-Gesellschaft, Berlin.

Japan's New Radio Tower

The reinforced-concrete wireless tower built at Tokyo for the Japanese government is said to be the highest monolithic structure in the world. It reaches 660 ft. above ground and tapers from 55 ft. in diameter at the bottom to 4 ft. at the top. The corresponding thicknesses of the shell are 33 in. and 6 in. The footings extend to a depth of 12 ft. and have an area of about 6,000 sq. ft., resting on gravel and clay. The work required about 6,000 cu. yd. of concrete and 425 tons of steel.

Telephones and Population

The Assistant Postmaster-General of the United Kingdom, answering a parliamentary inquiry recently, said that the total number of telephones in service in the British Isles on Dec. 31, 1920, was 988,500 and in the United States approximately 13,500,000. The ratio of telephones to population was one telephone to every forty-seven inhabitants in the United Kingdom and one to every eight inhabitants in the United States. Under the British plan of government ownership, an English telephone engineer adds, the Post Office Department telephone system can barely make ends meet and can promise to do that for the next few years only by almost doubling the rates.

New Electric Railways in Japan

The Mushashi Electric Tramway Company, recently organized, according to the *Japan Advertiser,* will construct and operate a new electric railway from Tokyo to Yokohama, running approximately 1½ miles inland from the present railroad. The company will also furnish electricity to the villages along the route. Plans are being made, according to a translation from the Nagoya Shimbun, for the construction of a railroad between Nagoya and Yamada, a distance of 61 miles. Power is to be supplied by the Ibugawa Electric Power Company. Another line 30 miles long, around the Chita Peninsula, is planned by a company to be capitalized at 4,000,000 to 5,000,000 yen. A translation from the Osaka Mainichi Shimbun reports a project for the construction of an electric railway between Nagoya and Gifu. It is proposed to construct a double-track line paralleling the present steam railway, at a cost of about 7,000,000 yen.

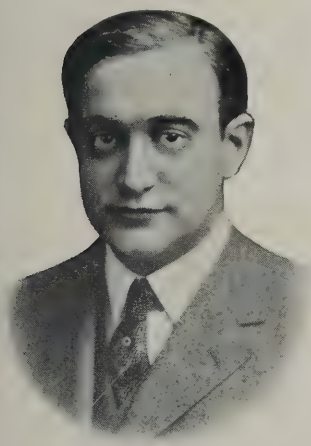
Personals

H. G. Thompson, who resigned from the Edison Storage Battery Company in the fall of 1919 to form the Transportation Engineering Corporation, of which he was elected president, has been appointed sales manager of the American Radio Research Corporation, Medford Hills, Mass. Mr. Thompson has been identified with the storage-battery field for many years, particularly in its application to train lighting and other railway uses. He was born in Massachusetts in 1875, and at the age of twenty-one entered the employ of the Pullman Car Company. Two years later he was advanced to be foreman of electricians. In 1905 he was employed by the Pennsylvania Railroad to take charge of car lighting at Jersey City. Later he became associated with the Safety Car Heating & Lighting Company, then with the railway department of the Westinghouse Storage Battery Company. In the spring of 1910 he joined the sales organization of the United States Light & Heating Company and later that year the Edison Storage Battery Company. He became manager of the railroad department and was elected vice-president of the company, and in 1915 was appointed general sales manager.

H. G. Thompson

A. P. Van Schaick has been appointed general manager of sales of the Page Steel & Wire Company, New York, succeeding E. C. Sattley, resigned. W. T. Kyle has been appointed assistant general manager of sales. The headquarters of both Mr. Van Schaick and Mr. Kyle are at the Grand Central Terminal, New York. All the company's general sales are now handled at New York for both the Adrian, Mich., and Monessen, Pa., plants.

Mr. Van Schaick began his business career in 1903 in the railroad sales department of the Pittsburgh Plate Glass Company, with headquarters in Chicago. From 1906 until 1910 he was in the employ of the Universal Railway Supply Company, with headquarters in the same city, resigning that position during the latter year to become district sales manager of the Lackawanna Steel Company at Chicago. In May, 1919, he went to the American Chain Company, Inc., Bridgeport, Conn., as special representative, with headquarters in Chicago, and was subsequently appointed assistant general manager of sales of the same company at New York. On January 1, 1921, he was promoted to general manager of sales of the American Chain Company and other subsidiary companies and now becomes also general manager of sales of the Page Steel & Wire Company. Mr. Van Schaick has been active in the work of railway supply organizations and especially of the National Railway Appliances Association, of which he was elected a member of the executive committee in 1910, vice-president in 1911, and president the following year.



A. P. Van Schaick

W. T. Kyle

Mr. Kyle was born at Baltimore, Md., in 1883, and began an apprenticeship course with the Bell Telephone Company, at Philadelphia, Pa., in 1901. Two years later he went with the American Pipe & Construction Company, Philadelphia, as district superintendent, on general railroad construction work. He left that position in 1908 to go to the Duplex Metals Company, New York, as a salesman, and later became sales manager of the same company. In 1914 he went to the Okonite Company as special representative at New York and in 1916 entered the service of the Page Steel & Wire Company as sales manager of its Armco wire department, which position he held at the time of his recent promotion. Mr. Kyle served in 1917 and 1918 as chairman of the Railway Signal Appliance Association and is now chairman of the Railway Telegraph & Telephone Appliance Association.

Ira Cushing is now associated with The Condit Electrical Mfg. Co., South Boston, Mass., as a sales specialist, paying particular attention to circuit breakers, switchboards, and switching arrangements. Mr. Cushing had been with the General Electric Co. for more than eighteen years up to last year, when he was sales-engineer representing the Three-E Co., in New England.

Obituary

E. E. Hudson, who was elected president of the Waterbury Battery Company, Waterbury, Conn., in March, 1921, died on June 27 at his home in Maplewood, N. J. Mr. Hudson for the past 22 years, with the exception of a little over a year's time, had been in the sales and managerial departments of concerns manufacturing primary batteries and had been identified with the installation of the primary battery. In July, 1898, he served as chief clerk in the primary battery sales department of the Edison Manufacturing Company, remaining in that position until June, 1902. Shortly afterward, he served as an accountant in the controller's department of the United States Steel Company. In December, 1903, he became secretary and treasurer of the Battery Supplies Company, Newark, N. J., and in 1905 was appointed sales manager of that company. When the Edison company absorbed the Battery Supplies Company, in 1908, he was appointed assistant manager of sales in the primary battery department. He became sales manager of that department in February, 1909, and in September, 1913, was elected also vice-president. In October, 1914, in addition to these duties, he was given charge of the manufacturing, as well as the sales, and in March, 1915, was made division manager in general charge of the entire primary battery business of Thomas A. Edison, Inc. In 1914, he was chairman of the Railway Telephone & Telegraph Appliance Association and in 1916, he was chairman of the Signal Appliance Association, previously having been a director. On January 1, 1917, he was elected vice-president and general manager of the Waterbury Battery Company and since March of this year was president of the same company.

E. E. Hudson

William H. Bloss, manager of the steam railroad sales department of the Ohio Brass Company, died very suddenly of heart trouble on June 22, at his home in Mansfield, Ohio. Mr. Bloss was born on April 4, 1869. He received his engineering training in the Indiana University. After graduation he became engaged in railroad work, and at one time was division engineer on the Santa Fe. Later he held a position as chief engineer of the Indiana Union Traction Company. Mr. Bloss' connection with the Ohio Brass Company dates from November 16, 1906, having been previously employed by the Buda Company of Chicago. His duties with the Ohio Brass Company were those of district sales manager in some of the central states until about a year ago. Since that time he had devoted his efforts to electrification developments and other steam railroad problems. Mr. Bloss enjoyed a wide acquaintance among electrical men on the steam railroads.

W. H. Bloss

Trade Publications

Trico Fuse Manufacturing Company, Milwaukee Wis., is distributing a number of small envelope folders devoted to the illustration and explanation of the Trico renewable cartridge fuses. The renewable element consists of a fuse length surrounded by an arc choking powder which kills the gases and prevents violent explosions.

The Electric Hoist Manufacturers' Association, New York City, has recently issued a 12-page illustrated bulletin devoted to a portrayal and description of approved applications of electric hoists. The pamphlet contains numerous photographs showing various types of electric hoists and hoisting apparatus in actual service at various industrial plants.

The Copper Clad Steel Company, Rankin, Pa., has recently issued a bulletin including the loading tables and characteristics of copperweld wire. These tables afford complete information as to the diameter cross-section, breaking load, allowable tension, load to lineal foot, elasticity and resistance of stranded, solid-bare and solid-weatherproof copper-clad wires.

Warren D. Spengler, Inc., Cleveland, Ohio, is distributing a number of envelope folders, the general title of which is a series of engineering service talks. The first folder explains the advantage of periodical tests of equipment insulation, the second drying electrical equipment to restore insulation value and the third emphasizes the importance of analyzing power costs.

Benjamin electrical products are described and illustrated in a new catalog, No. 23, issued by the Benjamin Manufacturing Company, New York. The catalog lists such material as sockets and receptacles, attachment plugs, reflectors and reflector fixtures, signals, push buttons, portable lamps, panel boards with cabinets, water and moisture proof fittings and fixtures and marine panels and cabinets.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., has recently issued on 8-page bulletin printed in five colors in which is shown a new line of auto-transformer starters to be used in connection with squirrel cage induction motors in capacity from 5 hp. upward. The bulletin shows a number of photographs of both the inside and outside parts of the starters. The new line of auto-transformer starters is known as 9141. The new C-H inverse time limit overload relay is one of the features which is incorporated in the 9141 auto-transformer line.

Curtis steam turbines for driving circulating and boiler feed pumps, as well as centrifugal pumps for all purposes, fans, blowers and other apparatus, are described in Bulletin 42019, issued by the General Electric Company, Schenectady, N. Y. The bulletin includes a description of the principles involved in this turbine and a careful summary of its several parts, including wheel, shaft and buckets, wheel casing, bearings, packing, governor, governor valve, emergency governor and other elements.

Electric Arc Cutting & Welding Company, Newark, N. J., has recently issued a 52-page booklet entitled "Alternarc" Portable Welding & Cutting apparatus. The pamphlet is 7½ by 10½ in. and contains particulars of portable cutting and welding machines, electrodes, supplies and accessories manufactured by this company. The booklet is illustrated with many photographs of the equipment and of work performed by it, the subjects being chosen from the shipping industry, from the railroads and from various industrial applications such as steel mills, foundries, machine shops and boiler shops. Commercial job welding is also discussed. The advantages of welding with alternating current are outlined at some length. Diagrams are included showing the manner of connecting one or more machines to various types of alternating current systems.

General Electric Company, Schenectady, N. Y., has recently issued two bulletins, Nos. 41311A and 48032 respectively. The first of these describes and illustrates synchronous condensers and the second synchronous motor control apparatus and exciters. Some of the advantages of making the synchronous condenser a part of the power system for power factor control are mentioned in the first bulletin. Automatic starting and control equipment for synchronous condensers in places where it is not always possible to have attendants, is also described. Calculations necessary in figuring on synchronous condenser installations, a wiring diagram, and other data are included in the bulletin. The second bulletin, describing synchronous motor control apparatus and exciters, shows five standard types of direct-connected exciters and two types of belted exciters. Four general types of compensators for use with synchronous motors are described in detail, as is also the switchboard panel equipment and rheostats used in connection with this apparatus. Diagrams of connections, table and compensator dimensions and of compensators for use with different motor types are included.

Railway Electrical Engineer

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Although steam locomotives spend the greater part of their existence on the roads for which they were purchased, it cannot be denied that it is a tremendous advantage in cases of emergency to transfer motive power to other roads for temporary use. This versatility of service has no corresponding feature on the part of the electric locomotive. There is a deplorable lack of uniformity in almost every part of electrification projects. It is true, of course, that electrification is comparatively young, but in spite of that some things have been fairly well demonstrated. For example, the overhead trolley has been found to stand up under severe service. Why not take some steps to make overhead construction conform to a standard, at least so far as its mechanical construction is concerned? It is admitted that there are not so very many features in connection with different electrification projects that could be standardized, but the subject is one upon which much thought should be given in every new installation with the ultimate aim to make electrified lines of the future as flexible, with regard to their motive power units, as steam lines are at the present time.

Electrification Standards

A number of the railroads that adopted open crates for lead car lighting batteries a few years ago are beginning to show favor again to the solid battery crate. The open crates have a number of advantages, such as reduced labor charge at cleaning periods, lower cost, less weight, etc., and in some cases these advantages seem to be sufficient to warrant their continued use. In a number of cases, however, the larger number of leaky tanks which develop in the open crates has more than offset the advantages.

Open vs. Solid Battery Crates

The leaks usually develop in the bottom of the lead lining or in the sides near the bottom. Battery seals crack and a certain amount of electrolyte will get down around the bottom of the lining on the outside with resultant trouble due to electrolysis. If the lead is allowed to come in contact with the wood of the crate, it is apt to become pitted by the action of acetic acid from the wood. To prevent this a piece of roofing paper is placed between the tank and the crate. This helps the situation, but after a time the quality of the paper often changes so that it has most of the properties of a blotter and retains some of the acid, or electrolyte.

Successful use of the open crates undoubtedly depends upon the methods used, the conditions under which the battery must work and the quality and weight of the lead from which the tank is made. Many railroads have had splendid success with the open crates and their battery repair men declare they are better, but the general tendency seems to be to revert again to the use of the solid crate.

This probably accounts partly for the renewed interest in rubber battery jars. There are now a number of them on the market. Rubber jars have been used exclusively on the Atchison, Topeka & Santa Fe with 200 ampere-hour batteries for a long time. They have given excellent satisfaction and the cost of broken battery jars has been as low as 16 cents per car per month. The makers of the new types of rubber jars claim much in the way of increased mechanical strength, and if increased strength can be combined with a sufficiently low first cost, the rubber jar may easily become a serious competitor to the lead tank used with either type of battery crate.

Economy in railroad operation, as with everything else, depends upon the economies that are effected in the individual departments which compose the whole. Although the organization is, of course, greater than any one of its constituent parts, it is nevertheless impossible for it to function economically if some of its departments are careless in the discharge of their duties. This applies to the electrical department just as surely as it does to any of the larger departments, for even though the electrical forces may be relatively small on some roads, the work which is assigned to the electrical men is of such nature that much depends on its proper execution. Power houses, transmission lines, lighting installations, headlight and car lighting maintenance work, as well as numerous miscellaneous motor applications in shops, roundhouses and other buildings all have their missions to perform. Moreover, upon the proper functioning of this equipment depends the efficient execution of many other operations. The actual cost of neglected maintenance is such an intangible quantity that it is practically impossible to compute it with any degree of accuracy. It is, nevertheless, a very real expense and never fails to show up on the wrong side of the balance sheet.

Wasteful Economy

In these days when most stringent economies are being practiced by all roads, there is a tendency to reduce expenses by reducing the number of workmen. So far as casual appearances go, economy is gained by the practice. It is not always wise, however, to be guided entirely by superficial appearances. Virtue may be carried to such an extent that it becomes a vice, and it is quite an easy

matter to reduce the number of workmen to a point where an apparent saving is in reality a genuine expense.

It is not an easy matter to determine just how far forces can be reduced before financial loss actually begins. As a matter of fact, it is usually very difficult. Each case presents an individual problem and calls for an individual solution. Of all men to determine what the requirements of any maintenance problems are, there is none better situated than the foreman. He is close enough to the work to know the condition of the equipment at all times and should have a thorough knowledge of what is needed to keep it in efficient operating condition. The right sort of foreman will accumulate irrefutable data to prove that a reduction of his forces below a fixed point will be an expense and not a saving. Not only will he save money for his employer in this way, but he will incidentally demonstrate beyond question the fact that he is thoroughly familiar with his business.

Enginehouse Wiring Systems

Many ingenious methods of electric wiring have been applied to enginehouses, but the problem of putting in a system that is practical and will last is a difficult one; as yet no one has developed a system so much better than any of the others that it has been generally adopted. To meet requirements it must be rugged enough to stand a certain amount of mechanical abuse at points where it may be struck by objects moved about the enginehouse, and it must not deteriorate rapidly under the effect of the locomotive gases.

Wiring, all in conduit with and without vapor-proof fittings, has been tried extensively in enginehouses with somewhat doubtful success. If the conduit is run overhead on the roof trusses and rafters, the locomotive gases cause it to deteriorate rapidly even when efforts are made to prolong its life by painting. If the conduit to the extension outlets (and to the overhead lights, if used) is run underground, it will corrode and get broken in a comparatively short time at the point where the conduit goes into the ground, if it does not leak and go to pieces underground.

To avoid these difficulties one railroad has adopted the method of suspending the overhead conduit on messenger wires at a point high enough to be out of the way and low enough to be below the gas line the greater part of the time. Another road uses wood strips nailed between the roof supporting columns in place of the messenger wire.

The method now probably used more extensively than any of the others, employs open wiring overhead with conduit risers from the lighting units and extension outlets. The rubber covered wire used for the open wiring seems to withstand the action of the gases very well, and while the conduit risers stop below the gas line they protect the wiring against mechanical damage. In one instance where this type of wiring was employed the enginehouse doors became charged with electricity due to leakage over the surface of the knobs that held the overhead wire. This was corrected by wiping off the knobs and was probably caused by the fact that locomotives were blown off in the house.

Still another road is using lead covered duplex wire with conduit risers for protectors near the ground. The lead covered wire is secured to the roof members with lead straps and copper nails. This method is simple and bids fair to last a long time.

A number of the methods will be described in future issues of the *Railway Electrical Engineer,* and it is hoped that enough good points will be brought out to aid in furthering a movement to adopt a method of wiring that will be best for the great majority of conditions encountered in enginehouse wiring. If you have a method of wiring which has good points differing from those mentioned here, you will perform a service by notifying the *Railway Electrical Engineer.*

New Books

Proceedings, Engineering Association, American Electric Railway Association, 1920. One volume, 6 in. x 9 in.; illustrated. Published by The American Electric Railway Association. 8 West 40th street, New York.

The 1920 proceedings of the Engineering Association published in this book include a number of subjects which have been discussed in such a way as to be of general interest to railroad men. Among the committees reporting were those on Buildings and Structures, Equipment, Heavy Electric Traction, National Electric Safety Codes, Power Distribution, Power Generation, Standards and Way Matters.

Engineering Instruments and Meters. By Edgar Griffiths. 7 in. x 10 in. Bound in cloth. 360 pages, illustrated. Published by D. Van Nostrand Company, 8 Warren street, New York.

The writer in preparing the book has attempted to give a brief review of the appliances which have been devised for the measurement of length, screw threads, area, volume, velocity, force, mass, work, temperature, etc. The book should enable the reader to appreciate the advantages and drawbacks of the various types of instruments for making any particular measurement, and to choose the instrument best suited to his requirements.

Electrical Machinery. By C. A. Annett. 5 in. x 8 in. Bound in cloth. Published by McGraw-Hill Book Company, Inc., 239 West 39th street, New York.

This book contains a course of study in industrial electricity and is intended for home students and men engaged in the practical operation of electrical machinery. The author has made a special effort to present the subject in such a way that the students will avoid the difficulties which frequently occur in comprehending certain elementary laws, and has dealt with problems that occur in daily work. Much of the text appeared in "Power" as part of a series of articles entitled "Brief Electrical Study Course."

National Electrical Safety Cods. Issued by the U. S. Bureau of Standards. Third edition. Washington Government Printing Office, 1921. (Handbook Series No. 3.) 366 pages, 5x8 in. Bound in cloth.

About four years ago the Bureau of Standards published the completed text for this Code for examination and trial use, an early revision being contemplated. War conditions interfered with this trial, so that the publication of a new edition has been greatly delayed. The revision is now completed and the revised code is now published in this handbook for more convenient use. The discussion of the rules has been segregated under a separate cover so as to reduce the bulk of the main volume, and will appear as Bureau of Standards Handbook No. 4, now in press.

Night View of Yard Illuminated by High Mounted Units

Correct Illumination of Railway Freight Yards

Mounting Height of Lighting Units is of Prime Importance in Eliminating Glare and Obtaining Best Results

By J. H. Kurlander
Lighting Service Department, Edison Lamp Works, Harrison, N. J.

AS approximately 75 per cent of the revenue of railroads of the country is derived from the transportation of freight, it can easily be seen that anything tending to expedite the rapid handling of shipments of freight should receive careful consideration, in view of the large return afforded by it. Operation here is continuous and the lighting installation plays no small part

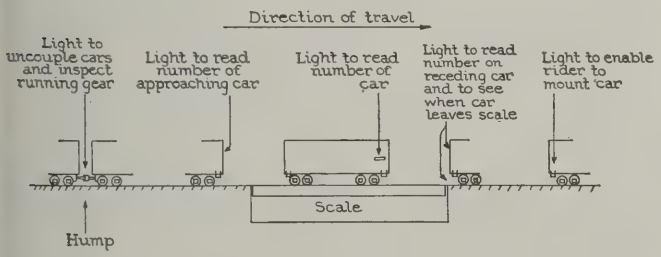

Direction of travel
Light to uncouple cars and inspect running gear
Light to read number of approaching car
Light to read number of car
Light to read number on receding car and to see when car leaves scale
Light to enable rider to mount car
Scale
Hump

Fig. 1—Requirements for Proper Scale Lighting

in being one of the deciding factors in facilitating rapid shipment of freight.

There are two main applications of light; these are the scalehouse and its immediate vicinity and the classification and receiving yards. Both require very careful consideration as the requirements are rather exact.

The tendency today is to use multiple lamps in both cases in order to avoid running high voltage lines around the yard. The principal requirements for scale lighting are shown diagrammatically in Fig. 1.

In the scalehouse, the beam and counterpoise must be clearly visible and at no point should glaring light sources or reflections be present; particularly so from the scale master's stand. The lighting installation of the scalehouse serves two primary purposes, first to illuminate the cars as they approach, mount and leave the scale, and second to light the beam and counterpoise of the scale, and the scalehouse itself. Where a slight error in weighing will interrupt the operation of the entire movement of the cars across the scale, it can be easily seen that the lighting installation must be of the first order. In Fig. 2 is shown a method of scale lighting which has worked out satisfactorily in practice and is to be recommended for average conditions. In cases where the scalehouse has no extensions to permit the hanging of units from the side of the house, a framework of iron piping could be erected at a small expense for supporting these units.

The hanging heights of the units shown in this figure were calculated for the conditions of the scalehouse location and scale length, as shown. Where these dimensions vary greatly from those assumed in this case, it may be necessary, when installing the units, to adjust them as to direction of throw and height, in order to obtain the desired intensity on the sides of the cars during the weighing operation.

For lighting the scale beam and counterpoise a method which has given good results makes use of three low wattage mazda lamps placed in deep bowl metal reflectors, so that the skirt of the reflector entirely shields the lamp from the scale master's vision. These units, which are pendant, are hung 7 feet above the floor and approximately 12 in. to the front of and in a line parallel with the beam. The distance between units is approximately half the length of the scale beam.

The lighting of the yard proper is a problem the known

quantities of which are always variable. No specific set of rules can be given for its lighting for even its growth is in many cases somewhat difficult to predict. In its infancy it may be a siding and as the demands increase is added to from time to time until a full fledged yard is the result.

Practically every outdoor illuminant has been applied to the lighting of these yards. Some of the factors which have placed the incandescent lamp at the head of the list of available light sources are low maintenance requirements, easy replacement, comparatively fool proof construction and simple operation, together with its high efficiency.

Two methods of applying the incandescent lamp for yard lighting have been developed, one of which makes use of refractor units, and the other, floodlighting projectors. Each has its advantages and disadvantages, and each system has its adherents. One of the most serious objections to the use of floodlighting, when not properly employed, is the ever present glare evil. Where these units are mounted high, however, and their direction of throw is with or across the tracks and not opposite to the movements in the yard, their use for lighting large yards is recommended. For small yards the refractor units are to be preferred. In Figs. 3 and 4 are shown two methods of yard lighting. The first makes use of 300 watt mazda C multiple lamps in prismatic glass refractor units mounted not less than 30 feet high, in the case of narrow yards, and spaced approximately 200 feet apart. This system is particularly applicable to long, narrow yards whose width does not exceed 200 feet.

Where the width of the yard is greater than this and there is no opening in the center of the yard to permit the placing of another line of similar units, floodlighting projectors should then be resorted to in order to secure a desirable intensity. In Fig. 4 is shown a method of floodlighting employed for the same yard, the direction of throw of each floodlight being indicated by the arrows. It will be noticed that the units are staggered so that the individual cone of light from each floodlight fits into the neighboring ones, thus covering the entire yard. For this system 500 watt mazda C floodlighting lamps are used in projectors with a spread of approximately 50 degrees. The units are spaced 300 feet apart and should be mounted not less than 30 feet high. High mounting is always preferable in order to reduce glare to a minimum and keep shadows short. The 500 watt unit is applicable in yards of from 200 to 400 feet in width. Above 400 feet the 1000 watt mazda C multiple lamp should be employed in floodlighting projectors with suitable spacing and mounting height.

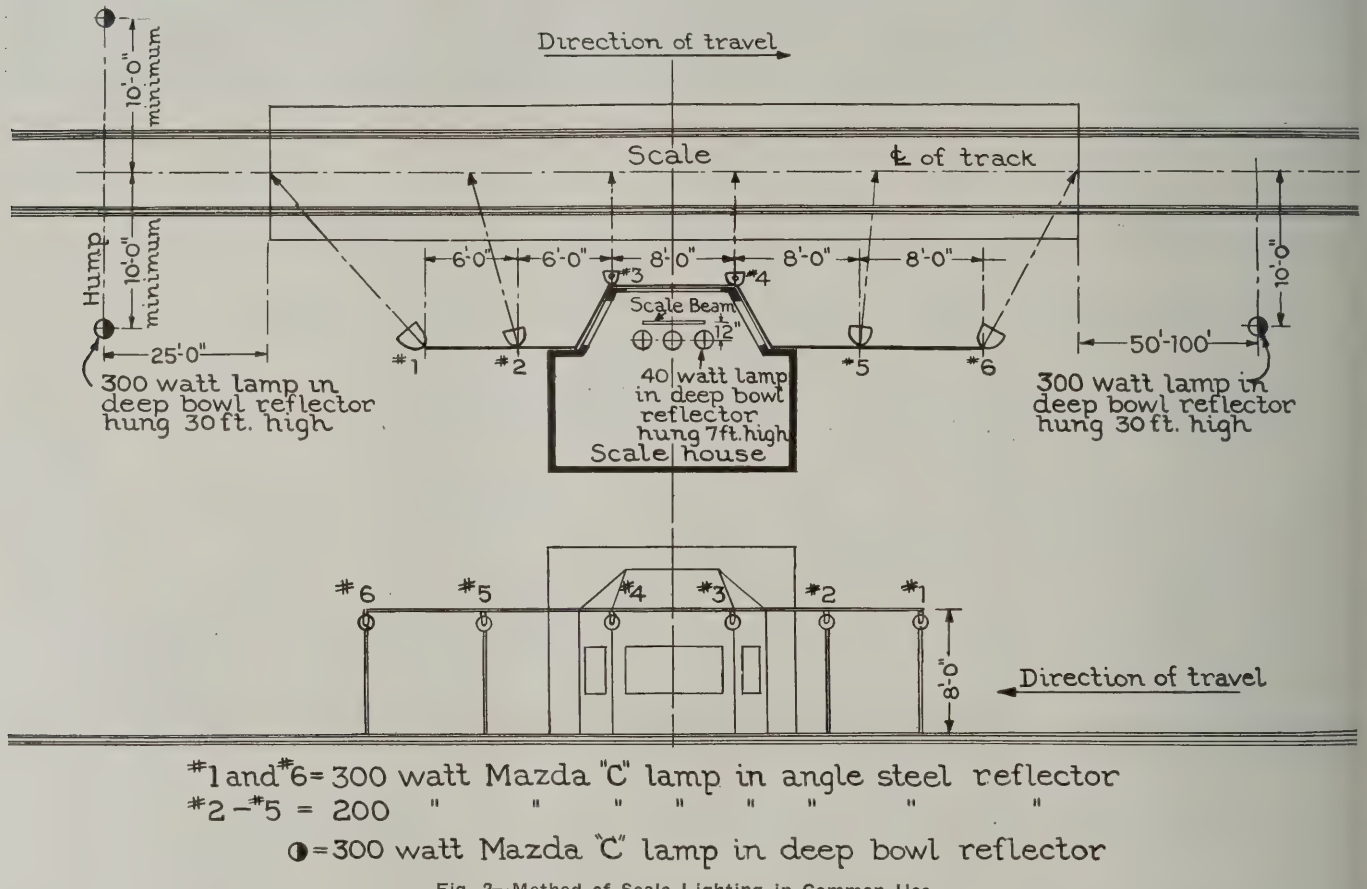


Fig. 2—Method of Scale Lighting in Common Use

Fig. 5 gives data pertaining to these three types of installation. The results from either type are bound to be satisfactory if sufficient light is employed.

One of the most important factors controlling the success of yard lighting installations is the hanging height of units. The two most exacting requirements of yard lighting can be satisfactorily met if the proper hanging height is obtainable. The two requirements referred to are as follows:

Illumination of every track irrespective of position of adjacent cars, and illumination of every car in the yard. A chart which shows at a glance the relation between proper hanging height and width of yard is given in Fig. 6. At the bottom of this diagram is shown probably the worst condition to be met with in yard lighting; a coal

car standing approximately in the center of the yard flanked on one side by a box car and on the other side, two tracks away, by another box car. By the simple projection of light rays (shown by dotted lines) to these cars from various heights to the side of the yard the correct hanging height at which these cars will all be illuminated can easily be determined.

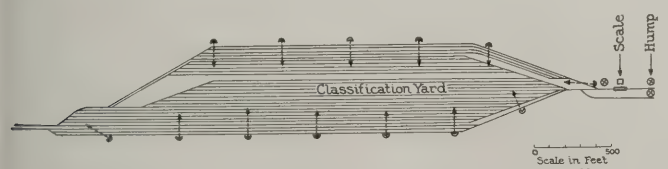
Another bad condition is that of lighting the area between box cars on adjacent tracks. No direct light from units strung along the sides of the yard can be expected to light this area. However, with a fairly high mounting

o-300 watt Mazda "C" multiple lamp in prismatic glass refractor.
⊗-300 watt Mazda "C" multiple lamp in deep bowl reflector.
Note: Hanging height of deep bowl units, 30 feet.
Minimum mounting height of refractor units, 30 feet.

Fig. 3—Plan Showing Method of Lighting Yard with Refractor Units

height, depending upon the width of the yard, direct light striking the upper edge of the box cars will be reflected and some light will reach the ground.

At the top of the diagram is shown these conditions applied to yards of widths ranging from that of four track yards to twenty-four track yards. The equivalent width of yard is given in feet directly below this so that in cases where the symmetrical arrangement as shown is not in effect, the yard width can be used directly for determining the correct mounting height of the units. This diagram is directly applicable to yards up to and including a twenty-four track yard, but for yards exceeding this width, lines can be drawn parallel to the ones already shown, thus obtaining hanging heights for yards up to twenty-eight tracks in width. It is exceedingdly doubtful whether yards having greater widths than this will not have openings in them which will permit running another line of units, thus picking up the area not covered by the other units. Example: suppose a fourteen track yard



⊕→= Floodlighting projector, 50° spread, equipped with 500 watt Mazda C floodlighting lamp.
⊗ = 300 watt Mazda C multiple lamp in deep bowl reflector.
Note: Hanging height of deep bowl units, 30 feet
Minimum mounting height of projectors, 30 feet

Fig. 4—Plan Showing Method of Lighting Yard

(180 feet in width) is to be illuminated; at half the width, seven tracks (or 90 feet) will be found a dotted line running to 38 feet, similarly for a twenty track yard, the height is seen to be 53 feet. These hanging heights will evidently meet the most extreme conditions and other less exacting requirements will be adequately provided for.

It will be noted from the diagram that narrow yards require hanging heights below 30 feet, but in order to avoid confusing enginemen and also to reduce glare to a minimum, hanging heights of units should, in no case, go below 30 feet.

In cases where mounting heights as shown cannot be obtained, the height nearest to this should be resorted to, but at heights less than those specified, it is evident that some of the worst conditions will not be satisfactorily met. In any event, the roofs of all of the box cars must be illuminated, to permit riders coming down the yard to distinguish cars and couple them with minimum danger of breakage to either car or cargo. In order to facilitate this, it is suggested that a narrow strip be painted in white on each end of the box car, both on the roof and on the end of the car. This simple practice will prevent a considerable amount of breakage.

In one case where special consideration was given to this problem and the lighting installation was designed to take this into account, a saving of fully 60 per cent was effected on breakage of rolling stock due to bumping of cars, with attendant increased safety to workmen.

Night pictures of yards showing the results obtainable with these two methods of lighting are shown in Figs. 7 and in the photograph at the beginning of this article. In Fig. 7 the units are mounted very low, about 22 feet, in fact, and the resulting glare is naturally objectionable. As stated elsewhere, the hanging height should in no case be less than thirty feet.

That high hangings are practical is proven by Fig. 8,

300 WATT MULTIPLE LAMP IN PRISMATIC REFRACTOR UNIT		500 WATT FLOODLIGHT LAMP IN FLOOD LIGHTING PROJECTOR SPREAD OF BEAM 50°		1000 WATT MULTIPLE LAMP IN FLOOD LIGHTING PROJECTOR SPREAD OF BEAM 30°	
WIDTH OF YARD	SPACING	WIDTH OF YARD	SPACING	WIDTH OF YARD	SPACING
30-200FT.	200 FT.	200 FT.	200 FT.	500 FT.	275 FT.
		250	230	600	330
		300	280	700	380
		350	330	800	430
		400	375	900	480
				1000	540

Fig. 5—Installation Data Covering Refractor Units and Projector Units

which shows a close-up of the poles used for supporting the units.

Turntables

The work of turning the table and engine does not demand a great amount of light, merely enough for safe operation to facilitate stopping the turntable at the proper point.

One scheme of lighting the table and adjoining area which is often employed but cannot have much said in its favor, employs 200 watt mazda C lamps in diffusing globes placed on the inner edge of the roundhouse roof, one unit to every three or four stalls. This method wastes the light, little reaching the turntable, the area between the table and the roundhouse receiving most of the light.

Another method makes use of floodlights mounted on the roof of the roundhouse, projecting light on the area involved. As these floodlights throw the light against the direction of traffic, however, a great deal of glare may be encountered.

The third and best scheme, especially applicable to half circle roundhouses, is to mount 500 watt mazda C lamps in deep bowl, porcelain enamel finish reflectors, on 35 or 40 ft. poles. Two such units are recommended, one on each side of the turntable, approximately 35 feet away from and slightly to the rear of it. To eliminate the likelihood of the area between the roundhouse and

the turntable being left in darkness by the blowing off of steam by locomotives while in the vicinity of the turntable, one floodlighting projector with a factory ribbed glass front cover to minimize glare should be mounted on the center of the roundhouse. For turntable above 60 feet, it is advisable to mount a 100 watt mazda C lamp in an RLM dome reflector with weatherproof holder on an iron pipe standard approximately 9 feet high on each end of the table.

In the case of full circle roundhouses, poles cannot be conveniently placed without interfering with the track arrangement. The use of floodlights placed on the roundhouse must be resorted to in such cases, but they should be equipped with factory ribbed glass to throw the light in a broad band on the area immediately encircling the turntable.

Coaling Stations

This type of building consists primarily of a track shed in which loaded coal cars are run, the coal then being dumped into a pit beneath the car, from which it is raised mechanically by a conveyer and carried over to the storage pockets adjoining the track shed. From these pockets the coal is loaded by means of chutes onto the tenders. Adjoining the opposite side of the track shed is a sand storage bin from which sand is conveyed to a pocket adjacent to the coal storage pockets for loading on the locomotives. Fig. 9 shows a typical coaling station, together with the arrangement of the outlets. It will be noted that in all covered portions of the coaling station 100 watt mazda C lamps in RLM dome reflectors are recommended, while for the outdoor or uncovered parts 200 watt mazda C lamps' RLM standard dome reflectors are called for. Plug outlets are provided for the insertion of trouble lamps at frequent intervals where construction of the station is such as to render local lights necessary at those points.

Stations

Terminals and Train Sheds.—At the end of all divisions are found structures commonly referred to as passenger terminals. These may vary in size and construction from the simple, unpretentious buildings to magnificent structures of granite and marble, occupying an entire city square, making it a veritable city in itself. Aside from the ornateness of these buildings there is also attached a certain advertising value, as a structure of this kind becomes known and talked of over the entire country. Since it is in use practically all hours of the day, it is no small part that the lighting plays in the impressions created on the traveling public. Not only must light in abundance be provided but the installation as a whole must be in harmony with the architecture.

The principal requirement for lighting outside of the spectacular element is that of furnishing adequate illumination throughout the entire waiting room to see to read for short periods of time with ease and experience the general comfort of being in a well lighted interior. There are points, such as the ticket windows, bulletin boards and entrance to train platforms where efficiency of operation demands a high intensity of illumination. To make change and sell tickets speedily and with accuracy, and to examine tickets with speed makes it desirable to have local lighting at these points.

The form taken by the general lighting system can indeed be varied. Direct lighting from central chandeliers or massive fixtures, enclosing units of suitable size, semi-indirect, totally indirect, cornice lighting and other systems have all been employed with differing degrees of success. It is quite outside of the province of this article

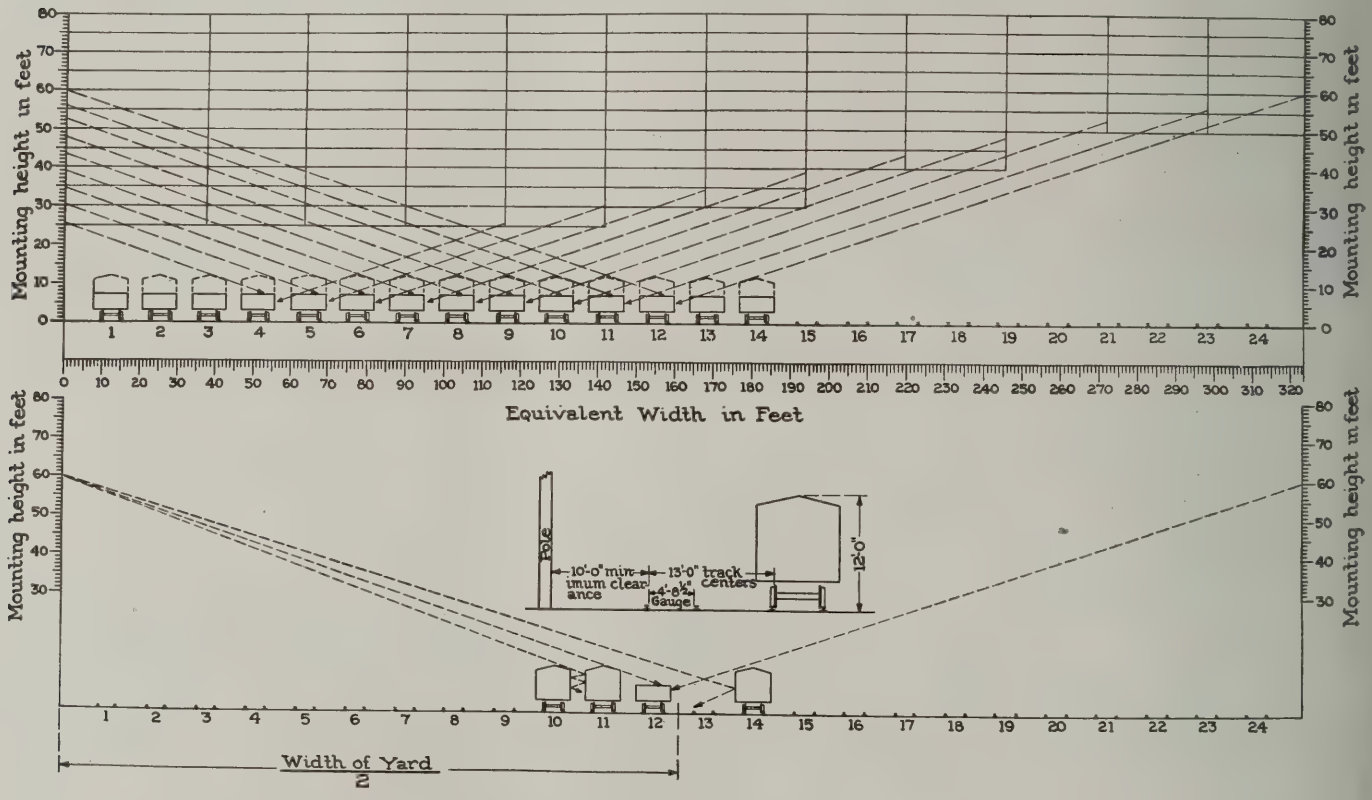


Fig. 6—Chart Showing Correct Hanging Heights of Units for Proper Yard Lighting

to attempt to lay down any broad rules. In view of the massiveness of the structure and ornateness of design, each problem should be given individual attention. It is well to bear in mind that the light colored surroundings usually employed act as reflecting and diffusing media, and unless care be taken in the design, a flat appearance of distortion of perspective may result.

On the other hand, the light surroundings make the utilization fairly high and tend to provide adequate intensities with a minimum wattage.

Unshielded lamps in the field of view should, of course, be avoided and care should be taken to eliminate glaring reflections from polished marble or similar objects.

The local lighting provided at the points above men-

Fig. 7—Night View of Yard Lighted by 600 cp. 6.6-20 Ampere Series Mazda C Lamps in Dome Reflectors and Rippled Globes, Mounted 22 Feet High and Spaced Approximately 175 Feet Apart.

tioned should be of such a character that the lamps are not visible and where possible the type of fixture employed should harmonize with the main or overhead units.

The concourse should also be harmonious with the main waiting room, while special lighting should be provided in the stores and offices.

Train Sheds

Besides furnishing means of ingress to and egress from coaches, train platforms are also used for trucking purposes, which necessitates using a higher intensity than that required for safe walking conditions along passageways. Particular attention must be paid to the location and equipment on the stairways. Many a claim is made against a railroad for a fall which is directly due to a temporary blinding from a glaring light source. Exposed lamps in such places are a true form of negligence. All pieces of baggage have checks attached to them on each of which is marked such information as destination of baggage, sender, weight, contents, etc. Many of these checks are colored and the intensity should be high enough to afford easy reading of them. The distribution of light should be fairly even over the entire length of the platform, inasmuch as the position of trains with regard to the platform is not fixed. Sufficient light should be thrown on the steps of the cars, particularly the outer edges, to prevent stumbling or misstepping. Approximately a ¼ watt per square foot of platform surface is sufficient and may best be supplied by 200 watt clear mazda C lamps in deep bowl porcelain-enameled finish reflectors, spaced thirty feet apart on the center line of the platform and hung 20 feet high. This would provide ample illumination for all ordinary purposes, allowing for a reasonable depreciation due to coatings of dust on lamp and reflector surface, resulting from smoky conditions where steam locomotives come into the terminal.

Way Stations

These may vary in size from small, one story structures of country towns to buildings approaching in size that of a small terminal. They can be effectively lighted by semi-enclosing or enclosing diffusing units, uniformly spaced with as high hanging as possible, and about two foot candles should be provided throughout the room with local lighting at the ticket windows.

There are two general types of way station platforms; one is commonly known as the umbrella type, which consists primarily of an inverted V-shaped roof, supported by a line of columns on the center line of the roof. As the supporting columns are spaced approximately 15 feet apart and the platform is about 15 feet wide, a single row of 100 watt bowl enameled mazda C lamps in RLM dome reflectors, spaced 30 feet apart and mounted not less than 10 feet high, will provide good lighting for the platform such as to enable passengers to mount coaches

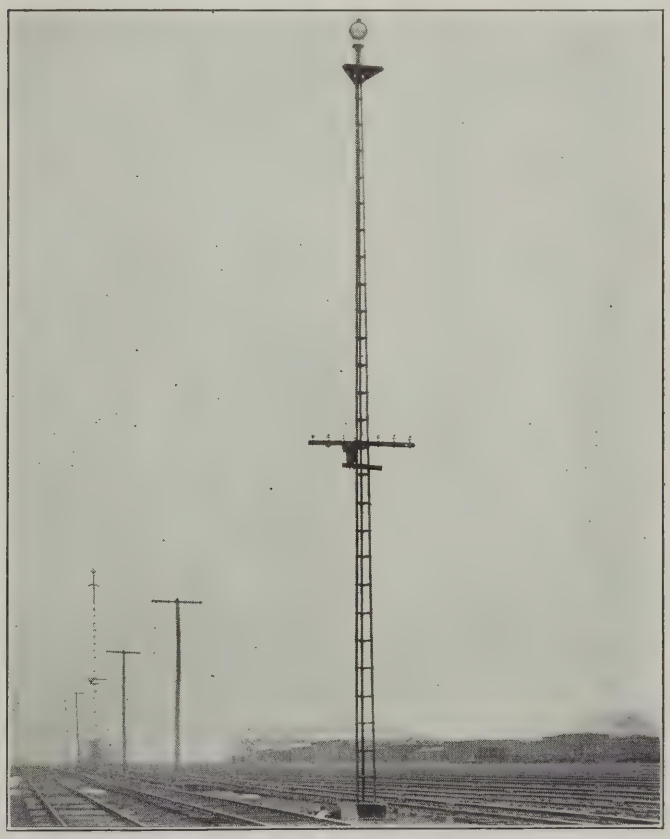


Fig. 8—Day View of Yard Shown at Beginning of the Article

in safety and to facilitate general trucking of baggage around the platform.

The second type of platform is one that has no roof and bracket units are recommended, employing 75 or 100 watt mazda C bowl enameled lamps in shallow dome reflectors spaced approximately 25 feet apart.

Freight Station and Loading Platforms

Inadequate illumination is often the primary cause of missent shipments of goods, resulting in tie-ups and loss

of money, other than that due to the particular pieces missent. Good lighting for this purpose requires between ¼ and ½ watt per square foot of floor area. This lighting should be provided by efficient lamps placed in suitable reflectors of durable construction which can be easily maintained.

As goods are often piled nearly to the ceiling a strictly general system of illumination is in many cases impracticable, but the aisles and passageways should be lighted to a fairly high intensity in order to read labels, check destination, and trucking, etc. The lighting of the passageways can easily be accomplished by 75, 100 or 150 watt mazda C lamps in RLM standard dome reflectors. With a low ceiling height of ten feet or less, the spacing should be approximately 15 feet and 75 watt lamps should be used. The 100 watt mazda C lamp is satisfactory where the spacing is approximately 20 feet and the hanging height from 10 to 15 feet. The 150 watt mazda C lamp can be used where the ceiling height exceeds 15 feet and the spacing is approximately 30 feet.

Loading platform lighting makes no special demands other than providing light enough to facilitate easy moving of freight to box cars on adjacent sidings and ordinary safety requirements. Here again, in the case of roofed over structures, the ceiling height plays an important part in determining the size of lamp and spacing. For low spacings, ten feet or under, the size of lamp should not exceed 100 watts and the spacing should be limited to 15 feet. For a ceiling height approaching 15 feet excellent results can be obtained by using either 200 or 300 watt mazda C lamps in opalescent diffusing globes, hung close to the ceiling and spaced 30 and 40 feet apart. Fig. 12 shows a night view of such an installation.

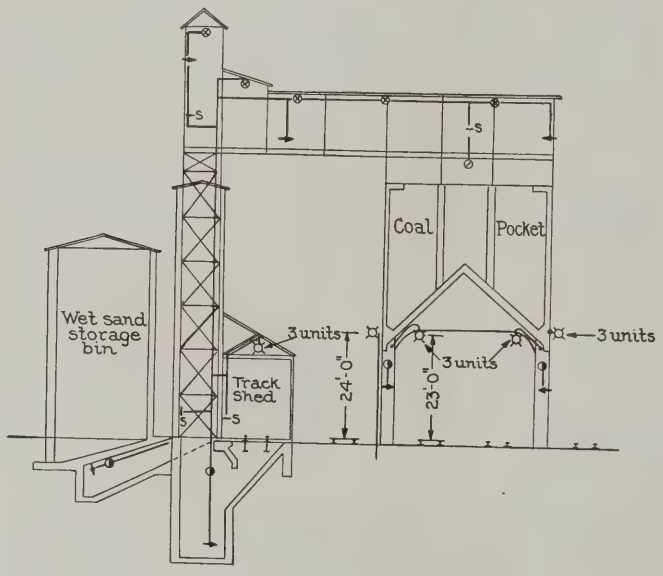


Fig. 9—Section of Coaling Station Showing Location of Outlets

The lighting of the interiors of the box cars can be accomplished by means of extension cords and 50 watt mazda B lamps. These extension lamps can be provided with a hook to permit their hanging from the roof and can be run from socket receptacles placed along the track edge of the platform, a trifle below the level of the car door.

Special Considerations

Repair Pits.—For lighting repair pits, 40 or 50 watt bare mazda B lamps can be used in sockets placed in niches in the walls for general lighting. Local lighting can be taken care of by means of lamps on extension cords run from side wall receptacles. In order to cut down glare as much as possible, it is advisable that these lamps be all frosted.

Fig. 10—Day View of Large Terminal with Installation of Two Main Chandeliers Studded with 50-Watt White Mazda Lamps

Oil Torches vs. Portable Lamps

The practice of using oil hand torches in engine houses and erecting shops when working on the interior of locomotive boilers where the light from overhead units cannot penetrate is adhered to by quite a number of companies. The thought suggests itself that railroad lines thoroughly up-to-date and modern in every respect as to rolling stock, shops and equipment, would find more suitable means for supplying proper lighting equipment for use where the ordinary lighting installation is ineffective. On the surface of it, however, the problem is not quite so simple. The most effective and economical rival of the hand oil torch is the portable incandescent lamp, but most operators prefer using the oil hand lamps and so avoid the necessity of dragging many feet of extension cord behind them wherever they may chance to move, with the likelihood of this cord becoming tangled around obstructions, being caught in crevices, run over by trucks or engines and being destroyed—which not infrequently happens.

The oil hand lamp at best is but a makeshift. Its light is comparatively feeble and the open flame introduces a personal fire hazard which together with the smoking of the lamp do not leave much to its advantage other than its portableness and ease of handling.

If a little thought were given to the portable incandescent lamp unit application to such uses described it would find more favor. One great drawback to its general use is that the cord becomes broken or otherwise

damaged, which results in considerable delay and annoyance. Obviously, if this fault is corrected, its biggest disadvantage is eliminated. It is suggested that some form of armored cable or protecting carrier be used on the cord to enable it to withstand handling and rough

Fig. 11—Night View of Way Station Lighted by Four 300-Watt Mazda C Lamps in Prismatic Glass Enclosing Globes Placed at the Corner of a Diamond Shaped Rectangle. Units are Hung About 20 Feet High.

usage. The lamp itself should be provided with a metallic guard for protection and a metal hook to permit its being hung from pipes, projections, etc. The increase in light provided by an incandescent light extension unit over that from an oil hand torch is enough to warrant its extra trouble in handling, and after operators become accustomed to using such a unit the oil hand lamp will seem but a poor substitute at best.

Electric Hand Lanterns

The use of oil hand lanterns for yard service is attended by a certain amount of fire risk in movements in-

Fig. 12—Night View of a Loading Platform, 220 Feet Long, Lighted by Five 300-Watt Mazda C Lamps. These Lamps are Enclosed in Opalescent Diffusing Globes and are Suspended Close to the 16 Foot Ceiling.

volving the make-up of trains containing loaded oil cars. The element of safety here is of such importance and loss from a possible fire so great that it is well to take extra precautions when handling these cars.

The use of electric hand lanterns for such cases where the fire risk is so great is coming more into vogue and in some instances special lanterns have been designed to meet this need. Such a unit is shown in Fig. 13.

Maintenance

Railroad companies have extensive departments for the purpose of keeping the roadbed, bridges, rolling stock, etc., thoroughly up-to-date. Many times, however, this fundamental principle of efficient operation is not extended to unobtrusive, but no less important parts of shop equipment. A lighting installation can only perform satisfactorily if it receives a reasonable degree of maintenance in the form of reflector and lamp cleaning, refilling empty sockets, replacing lamps whose useful life has been exceeded, etc. While a faulty lighting installation may not constitute a direct hazard to the lives of workmen, yet it is an indirect contributing cause to many accidents which could otherwise have been prevented had proper lighting been used. It is only under an efficient, well maintained lighting installation that work can be conducted properly.

Fig. 13—Electric Hand Lantern

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Electric Arc Welding in Railroad Shops

Explanation of the Characteristics of Arc Deposited Metal and Some Samples of Welding

By A. M. Candy
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ALTHOUGH much has been written concerning the application of arc welding to railroad equipment, many roads have not applied the process as extensively as possible. There is room for improvement in the quality of electric welds and the best methods of producing consistently good welds are of vital importance to managements, supervisors and welders. With this fact in mind a brief review of the characteristics of good arc deposited metal will be given, showing how metal can be improved by proper procedure and control of the process. A few important applications of arc welding are also illustrated.

Determining the Characteristics of Deposited Metal

To determine the characteristics of arc deposited metal put down under various conditions and in various ways, a number of large masses of metal were built up on steel plates. In one case each layer was brushed off thoroughly with a wire brush and in the other case each layer was cleaned off thoroughly by sand blasting. Standard 5-in. test specimens were turned out of the solid deposited metal and tested, the results being as follows:

Wire Brushed Samples

Test	Pounds per sq. in.			Per cent	
	Ultimate tensile strength	Yield point	Elastic limit	Elongation in 2 in.	Reduction of area
No. 1	58,825	41,000	40,000	8.2	19.9
No. 2	54,650	35,000	29,000	6.5	13.4

Sand Blasted Samples

Test	Pounds per sq. in.			Per cent	
	Ultimate tensile strength	Yield point	Elastic limit	Elongation in 2 in.	Reduction of area
No. 5	56,075	35,875	29,000	16	23.4
No. 6	58,225	.....	.....	18	27.8

The fractures of all these specimens had the appearance of high grade partially annealed low carbon cast steel. It is interesting to compare tests No. 5 and 6 with No. 1 and 2 and observe that while sand-blasting the layers of metal did not appreciably affect the tensile strength, it did practically double the elasticity of the metal as indicated by the increase in per cent elongation and reduction of area.

To determine the effect of the direction of metal deposition on the strength of a weld, three blocks of deposited metal were built up on steel plates as indicated at *A, B* and *C,* Fig. 1. Standard 5-in. tensile test pieces were turned out of these solid blocks of deposited metal. Those from Specimen A stressed the metal in the direction of the strings of deposited metal. Those from Specimen C stressed the metal at right angles with the direction of the strings of deposited metal. Those from

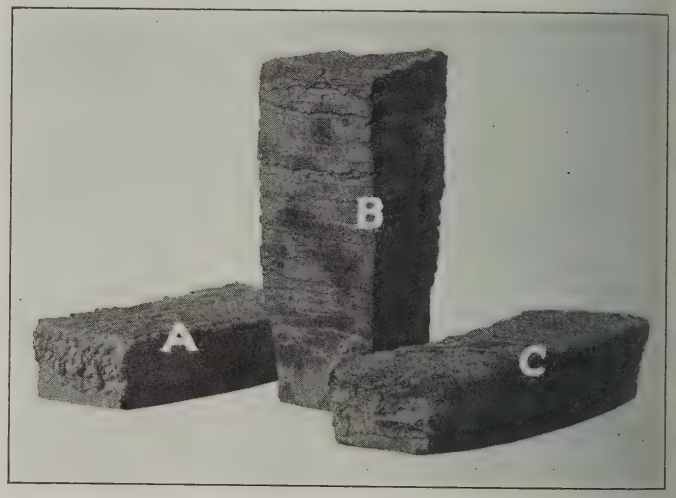


Fig. 1—Deposited Metal Built Up on Steel Plates to Determine Effect of Direction of Metal Deposition on Strength of Weld

Specimen B stressed the metal at right angles to the layers of deposited metal. The result of the tests on these specimens were as follows:

Tensile Tests

Specimen	Pounds per sq. inch			Per cent	
	Ultimate tensile strength	Yield point	Elastic limit	Elongation	Reduction of area
No. 1	56,000	33,400	27,500	18.1	30.8
No. 1	56,075	35,875	29,000	17.0	23.4
No. 1	58,225	.....	.....	18.0	27.8
No. 3	51,375	29,050	24,000	14.1	18.8
No. 2	40,875	29,400	24,250	4.4	15.9
No. 2	43,500	28,900	20,000	4.9	7.0

Compression Tests

Specimen	Load at 10 per cent compression pounds per sq. inch	Elastic limit pounds per sq. inch
No. 1	63,250	32,000
No. 3	60,750	30,700
No. 2	60,700	30,400

Shearing Tests

Specimen	Stress at shear pounds per sq. inch
No. 1	39,200
No. 3	41,450
No. 2	38,500

To determine the effect of forging on arc deposited metal, a sample similar to *C,* Fig. 1, was prepared so that standard 5-in. test pieces could be cut from it and

leave a sufficient amount of stock for forging before cutting additional test pieces. The results of tensile tests on the unforged and forged portions of this specimen are as follows:

Specimen portion	Pounds per square inch: Ultimate tensile strength	Yield point	Elastic limit	Per cent: Elongation	Reduction of area
Unforged ...	42,187	29,125	22,125	4.6	11.4
Forged	56,900	31,600	28,000	27.6	59.5

It is interesting to observe that the proper forging not only increased the strength of the metal from that of a

Fig. 2—Locomotive Mud Ring Reclaimed by Arc Welding

medium good weld to that of a very good weld but also improved the ductility to a marked degree, the per cent elongation being increased 500 per cent and the per cent reduction in area being increased 423 per cent.

Examples of Arc Welding on Locomotives

The mud ring of a locomotive boiler which has been badly corroded on the water side in service and which

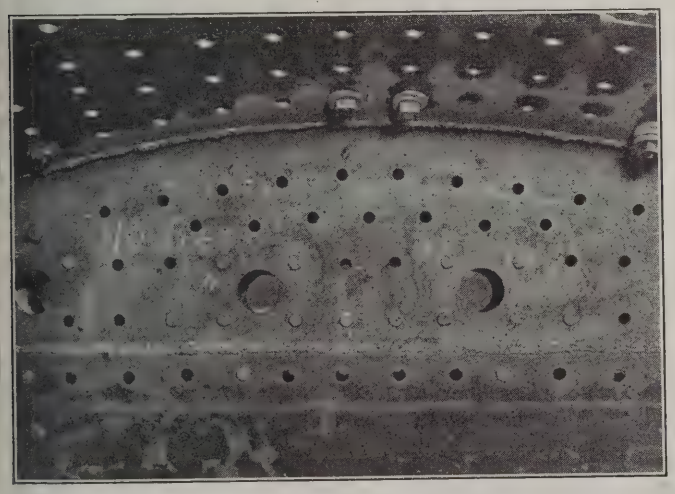


Fig. 3—Sample of Direct Overhead Welding at Junction of Crown Sheet and Fire Door Sheet in Locomotive Firebox

has been reclaimed by building up the corroded areas to their original shape and thickness is shown in Fig. 2.

The appearance of a set of neatly and effectively welded flues is familiar to all and this application of electric welding has proved a big money-saver for roads where bad water must be used. For this work to be successful, however, the operator must be skillful and know how to get good fusion. Welding flues is a rather exacting operation because the operator is forced to make a partial overhead weld under the lower edge of the tube. Before attempting to weld flues, the operator should make certain that none of the copper gaskets show beyond the edge of the bead. Most operators prefer to start at the bottom center and weld up around one side to the top center of the flue; then start at the bottom center and weld up around the other side to the top center.

A close view of a direct overhead weld at the junction of the crown sheet and fire door sheet in a locomotive fire box is shown in Fig. 3. Direct overhead welding is very difficult and requires an experienced operator with a steady hand and a welding generator which delivers a stable, tenacious arc.

A typical example of cylinder welding is given in Fig. 4 which shows the cylinder wall V-ed out, studded and welded. The greatest advantage (aside from lower cost)

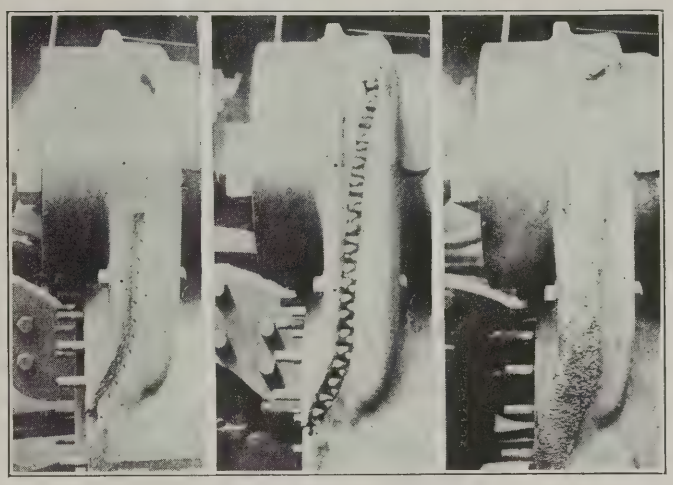


Fig. 4—Locomotive Cylinder Wall Beveled, Studded and Welded

claimed for electric over oxy-acetylene welding is that no preheating is necessary. Electric welding is valuable for many building operations such as the eye of a cross head which is badly worn. In this case the welding process is much more satisfactory and cheaper than bushing the hole. Piston heads can be made up of thin cast steel centers and cast iron rims beveled off so that metal fused into the groove will hold the two together, making a steam tight joint. Four holes are usually drilled in the steel centers near the groove and plug welded to give additional strength. Fig. 5 represents a locomotive deck plate the

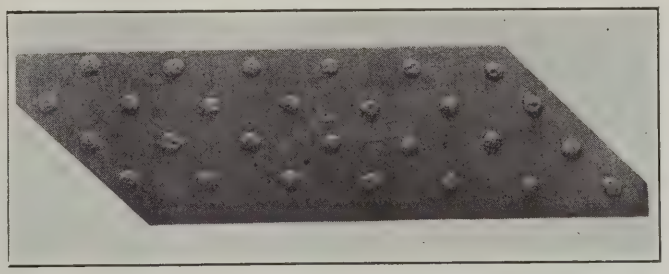


Fig. 5—Corrugations on Deck Plate Built Up by Arc Welding

corrugated impressions on which have been worn smooth and then built up as indicated.

The shafts of worn journals are sometimes built up by welding, but this is an emergency repair because the deposited metal will not have the same physical properties as the shaft steel. This is evidenced by Fig. 6 which is a section through a typical shaft. This section was polished and etched to show the deposited metal as the white layers on the outside. Immediately below are the black

scalloped shapes which are the portions of the shaft affected by the heat of the arc and deposited metal. These portions have been raised above the critical temperature and then rapidly cooled (quenched) by the rapid flow of heat into the main body of the shaft and also through the deposited metal to the air. The dark grey central portion represents that part of the shaft which has been unaffected. Subsequent heat treatment will reduce the hardened shaft area to its original condition but no amount of heat treatment will affect the deposited metal appreciably. Some very interesting and instructive data along this line was recently published by T. D. Sedwick, engineer of tests, Chicago, Rock Island & Pacific Railroad, on page 85 of the February, 1921, issue of the *Railway Electrical Engineer*.

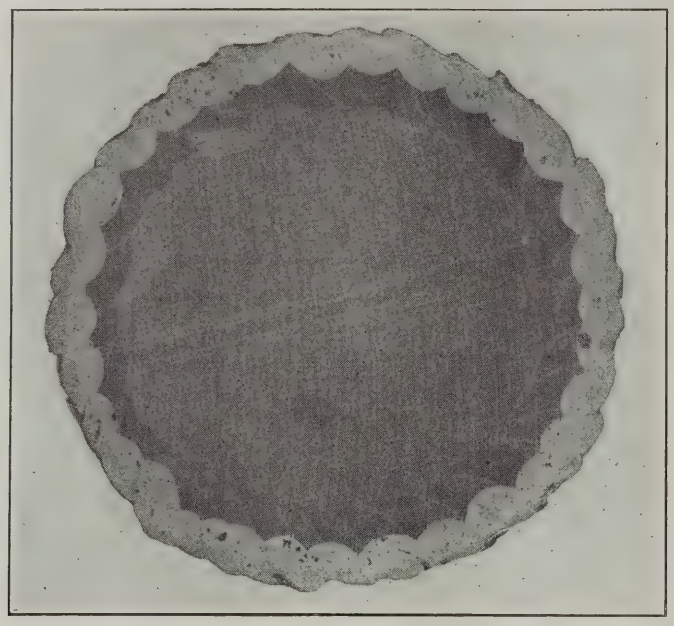


Fig. 6—Section Through Built-Up Shaft Showing Effect of Arc Welding

A car shop kink is illustrated in Fig. 7 which shows a section of car siding with finishing nails welded head on to the plate. Felt lining is pushed over the nails which are then clinched. In doing this work the positive side of the welding circuit is connected to the car body and a pair of pliers is connected to the negative side of the welding circuit. The operator grasps a finishing nail in the pliers and touches the head to the plate, withdrawing it to form an arc which produces a small puddle of metal in the plate and liquefies the end of the nail. The operator then pushes the nail head into the molten puddle and releases the pliers, leaving the nail welded in position.

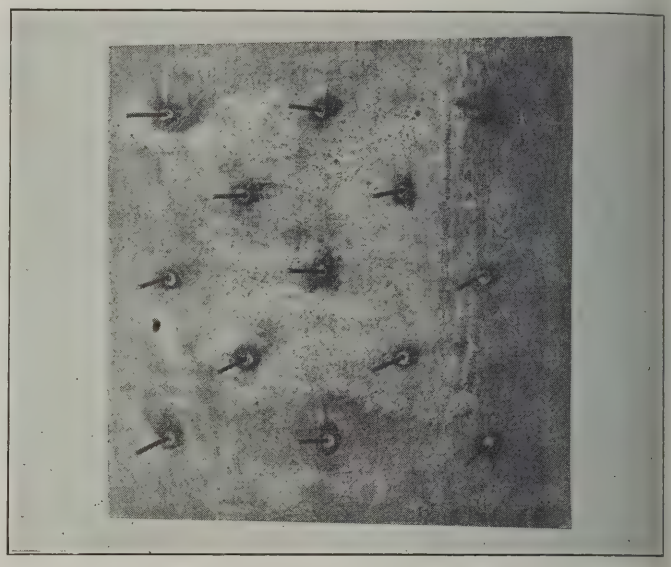


Fig. 7—Nails Welded to Car Side to Hold Felt Lining

Frame welding is another operation in railroad shops affording great possibilities of economy. A valuable feature of the electric arc for this work is the localization of heat, no allowance being necessary for contraction in cooling. In frame welding, quality is of the utmost importance and every care should be taken to improve as much as possible the characteristics of the arc deposited metal.

Photo by Ewing Galloway, N. Y.

Illinois Central Car Yards at Chicago

Principles of Car Lighting By Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

XIII. U. S. L. Type "A" Car Lighting Equipment

THE U. S. L. type "A" equipment has been designed especially for such passenger cars as require small lamp loads. In this class of cars will be found baggage cars, small coaches, combined baggage and smoking cars, and express cars. As a rule cars of these classes do not require more than a 15 ampere lamp load at 32 volts, employing 16 cells of rather small capacity. A load of 15 amperes at 32 volts represents about 480 watts, and taking the modern gas-filled lamp which develops about 1 c.p. per watt, it is possible to supply 480 c.p. actual illumination in cases of this kind. The storage batteries required do not ordinarily need to be of greater than 120 ampere hours capacity and even less, for such a battery represents an ability to carry a 15 ampere lamp load for eight full hours, which in this class of service is very exceptional. In most cases even smaller batteries than 120 ampere hours may be employed, even as small as 80 ampere hours for certain classes of service.

The generator has been designed with a view to securing a machine of light weight. So far as the working parts are concerned, the small generators contain every feature found in the larger machines, the difference being simply one of size and not of design or construction.

The regulating apparatus is mounted on a single slate or panel 26 in. by 12 in. The generator regulator and automatic switch are combined, which reduces two separate pieces of apparatus to a single unit.

The lamp regulator is made from the same frame and utilizes many of the parts found in the combined generator regulator and automatic switch.

The ampere hour meter may or may not be applied to these small equipments.

The battery consists of 16 cells for American practice where the 30 volt system is standard and of 12 cells for English and export practice when the 24 volt system prevails.

Generator

The type "A" generator is a plain shunt wound machine, designed to operate either in a 24 volt or a 30 volt system. It cuts in at 288 r.p.m. and carries full load at 320 r.p.m. in a 24 volt system. These speeds for a 30 volt system are respectively 360 r.p.m. and 400 r,p,m, It consists of a cylindrical steel casting universally machined so that it may be readily adapted either to a body suspension or to a truck suspension. See Fig. 1. By being universally machined, as it is called, the frame is finished as a smooth, cylindrical barrel and provided with certain tapped holes so that adapters for either body mounting or truck mounting may be attached to the frame without any further machining. Certain holes, of course, are employed when the body hung adapter is attached to the frame of the generator, and certain other holes are employed when adapters for truck mounting are applied. However, a majority of the holes are common to both methods of mounting, and the holes that are left vacant in either particular arrangement are plugged by means of hollow set screws which leave the surface of the generator smooth and clean, and do not in any way impair the appearance of the apparatus.

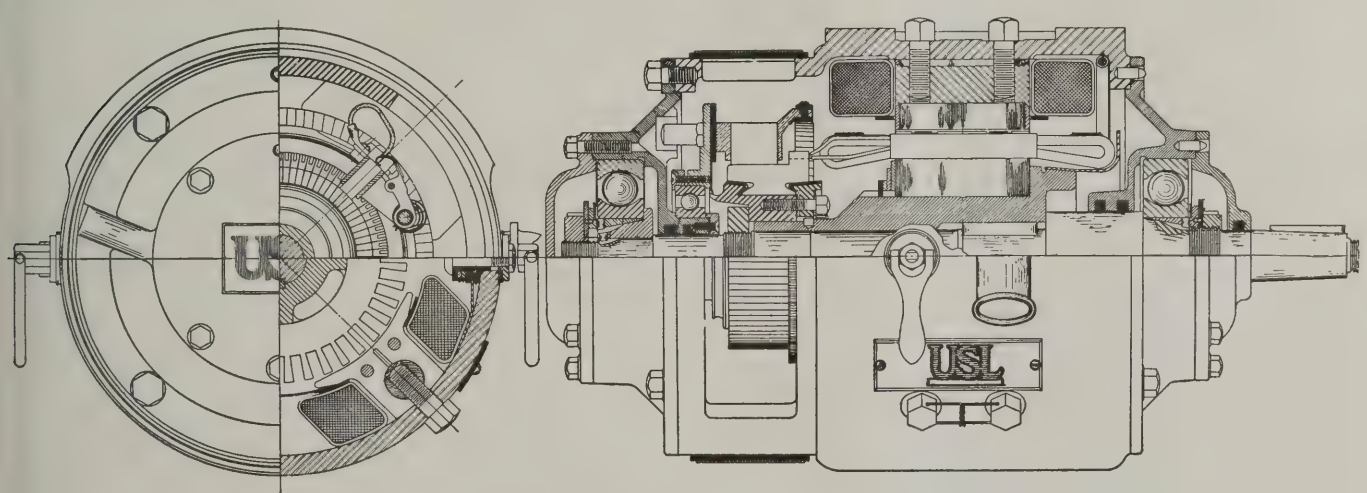


Fig. 1—Sectional Views of the Type "A" Generator

Cast iron housings are bolted to each end of the cylindrical frame and contain and support the ball bearings on which the armature shaft rotates. These housings are provided with caps which cover and protect the ball bearings and form grease pockets having a capacity for enough grease to last twelve months without necessity

for renewing the lubricating material. These housings are equipped with felt retaining gaskets, to prevent the escape of grease, and are perfectly machined, thus securing absolute alinement and concentricity of the armature in its bearings and in the pole pieces. There are two large hand holes, one on each side of the generator at the commutator end, which afford ready and ample access to the brushes and brush holders for inspection and renewal of brushes. The generator is equipped with the standard self-adjusting brushes mounted upon a brush rig supported on a ball bearing, which enables the brushes to be rocked back and forth with change of rotation of the armature, thus preserving the polarity of the terminals of the machine. The field poles are four in number and each is excited by its own coil. These field poles are all laminated and riveted together under very heavy pressure, so that the laminations form a practically solid mass. The field poles are bolted into the frame and the pole tips form retainers which hold the field coils in place.

The armature is of the standard toothed drum construction, the laminations being mounted upon a ventilated sleeve which also carries the commutator. The shaft is independently secured in the sleeve so that it may be removed without disturbing the relation of the armature and the commutator. The commutator bars are made of drop forged copper and a pure and soft grade of mica is employed for insulation. The retaining parts are all made of steel, so that there is no danger of breakage at any point. The armature shaft is made of high carbon steel.

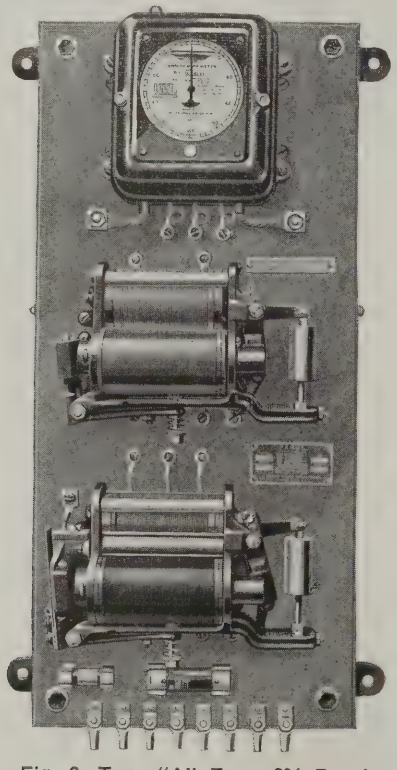


Fig. 2—Type "A" Form 201 Panel

The ball bearings and method of mounting same are shown in Fig. 1, the bearings used are No. 412.

Regulator Panel

The regulating apparatus is mounted upon a panel or slate and consists of two essential parts—the combined generator regulator and automatic switch, and the lamp regulator. See Fig. 2. The combined automatic switch and generator regulator, or potential regulator, as it is called, consists of a brass frame and two electro-magnets with iron cores, a carbon pile, a contracting armature, and a regulating armature. The cores of the magnets are arranged horizontally, and each core is provided with a coil consisting of two windings; one, a heavy or series winding and the other, a comparatively fine or potential winding. The potential windings are connected in series and across the terminals of the generator and they serve as the lifting coil for the automatic switch and as the voltage coil for the potential regulator. The

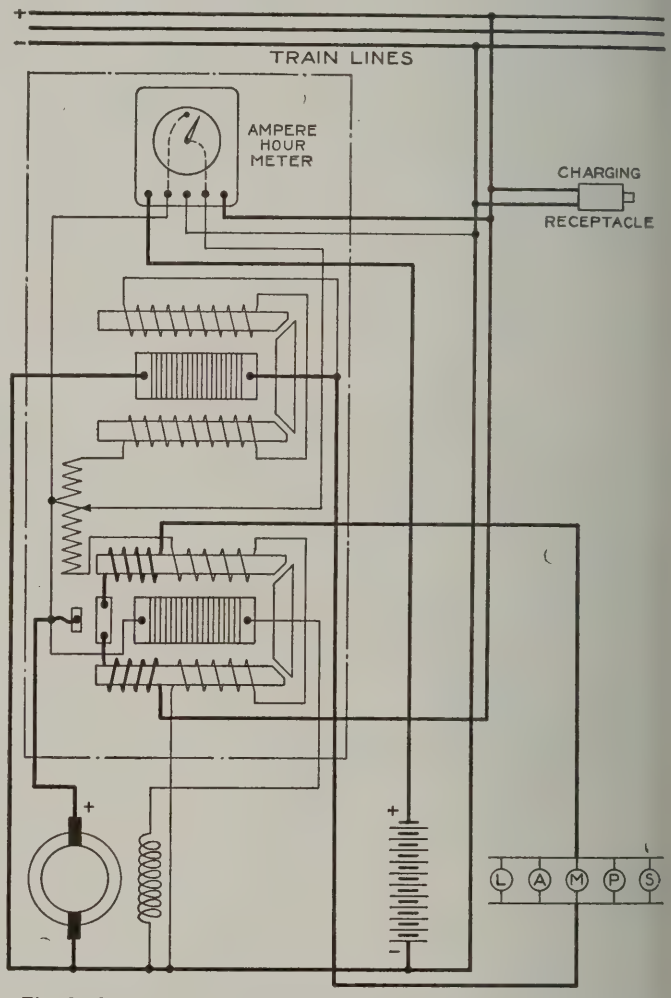


Fig. 3—Schematic Wiring Diagram of the Type "A" Equipment

two series coils are connected to a common insulated terminal on the automatic switch and one is placed in the battery circuit and the other in the lamp circuit. These coils act as the releasing coil of the automatic switch and perform the function of such coil, and also act as modifying coil to modify the effect of potential regulation, which is secured by the voltage windings previously described. The automatic switch consists of a bell crank lever to which is secured a soft iron armature. Attached to the vertical arm of the lever is a contacting laminated copper brush provided with auxiliary carbon contacts for closing the main circuit between the generator and the storage battery and lamps. The horizontal portion of the bell crank lever serves as a means of limiting the motion of the switch and adjusting the same. The armature of the automatic switch faces the left hand end

the magnet cores. At the right hand ends of the magnet cores is the regulating armature, which in turn is attached to a bell crank lever controlling the pressure on the stack of carbon discs which form the variable resistance in the field circuit of the generator. The magnet cores, at the right hand end, are beveled out on the inside to opposing faces and a wedge-shaped, laminated armature is employed for actuating the carbon pile. As before stated, this wedge-shaped armature is mounted on the vertical member of the bell crank lever, while the horizontal member is controlled by means of a vertical air dashpot. A normal tension or pressure is maintained on the carbon pile by means of a horizontal helical spring provided with nut and screw adjustment which is attached to vertical arm of the bell crank lever.

Operation

The operation of the apparatus will be readily understood by reference to the schematic wiring diagram, Fig. When the automatic switch is open the reluctance of the magnetic circuit through the cores, air gaps and armatures is so great that the voltage coils have no effect whatever upon the right hand armature which is used for controlling the pressure of the carbon pile. Consequently, during the time that the voltage is building up and the automatic switch is still open, while the voltage coils are excited on account of being connected directly across the generator terminals, they produce no effect on the armature which controls the carbon pile. After the automatic switch has closed, however, and its armature has come up into proximity with the left hand ends of the magnet cores, the reluctance of the magnetic circuit is so much decreased that a further increase in voltage impressed upon the voltage coils has the necessary effect upon the armature which controls the carbon pile, and from this point on regulation takes place, the tendency of the voltage coils being to maintain fairly constant voltage of the generator, which voltage is modified, however, by the action of the two series coils. The current flowing from the generator passes through the contacts of the automatic switch, thence into the two series coils on the regulator; and, as stated before, one of these series coils is in the lamp circuit and the other in the battery circuit. When the generator is furnishing the current for both these coils, they act cumulatively, and both tend to assist the voltage coils, thus producing a modified constant potential, as it is called. When the generator slows down below cutting-in speed the tendency of the battery is to discharge back through the automatic switch and generator, and, in doing so, the current through the series coil in the battery branch reverses and this, opposing the action of the voltage coils which tend to maintain the switch closed, causes the switch to open. The switch is adjustable so as to respond to whatever voltage may be desired, and this adjustment is effected by means of a spring on the horizontal arm of the bell crank lever which constitutes the armature mechanism. Likewise, the air gaps of the armature may be somewhat regulated for effecting still closer adjustment.

The carbon pile acts in the usual manner in which a carbon pile in the shunt field circuit of the generator functions; namely, that with increase in voltage the pressure on the carbon pile is diminished, which increases the resistance in the shunt field circuit of the generator, thereby reducing the voltage and current of same or preventing any further material increase in either of these. By means of the spring attached to the lever of the armature which actuates the carbon pile, the output of the generator and likewise its voltage may be varied through sufficient range to meet all the requirements of this equipment in actual service.

The lamp regulator consists of essentially the same parts as the combined generator or potential regulator and automatic switch, and employs the same type of frame magnet cores and substantially the same kind of armature and lever mechanisms, but a larger carbon pile; that is, the carbon discs are larger in diameter and in thickness, but the total length of the stack is about the same. The carbon pile of the lamp regulator is connected directly in series with the lamps, and the voltage coils are connected directly across the lamps. There are no series windings on the lamp regulator. The right hand lever of the lamp regulator actuates the carbon pile in substantially the same manner as in the generator regulator. The dashpot and adjusting springs used are the same, both for steadying and adjusting this armature. On the left hand end of the lamp regulator a lever mechanism, similar to the lever and armature mechanism of the automatic switch, is employed, but the main contacts are omitted. This armature forms a movable back yoke or keeper for the magnetic circuit of the lamp regulator and acts somewhat in the nature of a vernier, or multiplier, or agitator, depending upon the view one takes of it. The coils of the lamp regulator are not excited when the generator is at rest, and in this condition the armature or keeper on the left hand end of the lamp regulator falls back, due to the action of its retractile spring, and operates a back contact attached to the armature, by which the carbon pile is short-circuited and the intrinsic drop of same eliminated while the generator is at rest and the lamps are being fed directly from the storage battery. When the automatic switch closes, however, or due simply to the fact that the generator becomes operative, the coils of the lamp regulator are energized and the left hand armature is attracted toward the poles, thus closing to a certain extent the magnetic circuit and reducing the reluctance thereof. The right hand wedge-shaped armature which plays between poles fashioned similarly to those in the generator regulator is now free to act to vary the pressure upon the carbon pile, in order to maintain constant lamp voltage. With each change in lamp load there is a corresponding change in lamp voltage, and this change in lamp voltage of course changes the strength of the current in the coils of the lamp regulator. This is followed by a change in flux, which causes the change in the position of the left hand armature, and there is thus added an increased change in flux due to the fact that this armature moves toward or away from the poles of the magnet, as the case may be. This action stimulates or intensifies the normal action of the lamp regulator and serves to overcome the slight inaccuracy that is due to the mechanical friction in the working parts.

The voltage coils of both the lamp regulator and the combined automatic switch and generator regulator have connected with them, in series, high resistance units having zero temperature coefficient, thus reducing to a very small value the temperature error in these circuits. These resistances are made non-adjustable, and their values are determined at the factory. The only adjustment of the regulator is in the retractile springs and ready means is

made for varying the strength of tension of these springs so as to produce the requisite voltage in the lamps or output of the generator. It is not necessary to make any changes in the resistance in the circuits of the voltage coils in either of these regulators, nor is it necessary to make any change in the settings of the armature with respect to their air gaps. These adjustments having once been made at the factory are permanent.

The Ampere-Hour Meter

The ampere-hour meter is connected directly in circuit with the storage battery and measures the quantity of electricity charged into or discharged from the battery in ampere-hours. The ampere-hour meter has been thoroughly described in previous articles, both as to its mechanism, adjustments and its operation, and need not be further discussed here. The ampere-hour meter closes a pair of contacts when the pointer comes to zero, indicating that the battery is fully charged, and these contacts short-circuit a portion of an adjustable resistance in series with the shunt or voltage coils of the generator regulator and thus strengthen or increase the action of those coils and thus cause the generator regulator to operate at a lower potential. This potential is known as the *floating voltage* and is 34.75 volts. If the potential regulator is set to maintain approximately 35 volts after the ampere-hour meter has closed its contacts then no current will flow into or out of the battery, provided the latter is fully charged, which the closing of the ampere-hour meter contacts indicates. The battery under these conditions is said to float on the line. The generator remains in a condition that enables it to carry the lamp load without disturbing the floating condition of the battery.

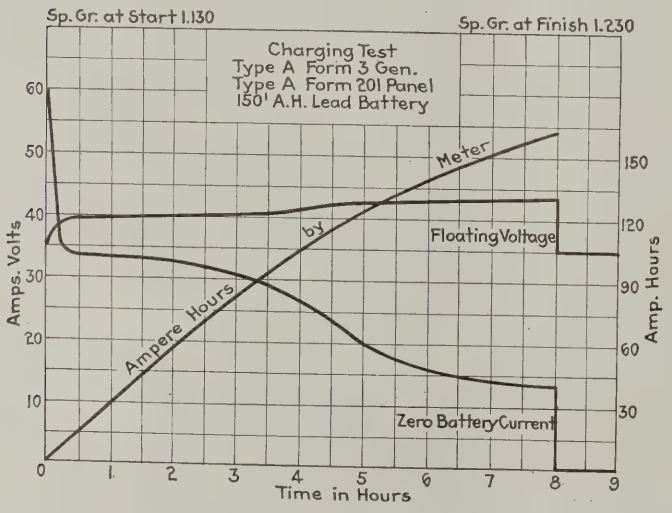


Fig. 4—Curves Showing the Relation Between Current and Voltage as the Regulator Charges 16 Cells of Lead Battery of 150-Ampere-hour Capacity

After a sufficient discharge has taken place at stations or stops the contacts of the ampere-hour meter separate and restore the generator to a charging condition, and thus the batteries are immediately replenished as soon as the generator becomes operative by reason of the car running again.

Curve sheet, Fig. 4, shows the relation between current and voltage as the regulator charges 16 cells of lead battery of 150 ampere-hour capacity. It will be noted that at the end of 8 hours the ampere-hour meter shows that 165 ampere-hours has been charged into the battery. At this time the contacts would close and reduce the voltage to floating value and the battery would float.

In some cases where strictly close lamp regulation is not necessary, the lamp regulator is omitted and certain fixed resistances are placed in series in each lamp circuit leading from the distributing panel. An auxiliary contact attached to the lever of the automatic switch is arranged to short-circuit these resistances when the generator is at rest and the lamps are being fed directly from the battery. When the generator is in operation and the automatic switch closed, these resistances are automatically thrown into the various lamp circuits and serve to protect these lamp circuits and lamps against excessive voltage. The use of these lamp resistances gives good results for certain classes of work, such as in baggage and express cars, where there is no clerical work to be done by artificial light and necessity for close lamp regulation is not imperative. The lamp resistance method of protecting the lamps is in most cases sufficient and it is somewhat cheaper initially, as the cost of the lamp regulator is considerably greater than the cost of the lamp resistances.

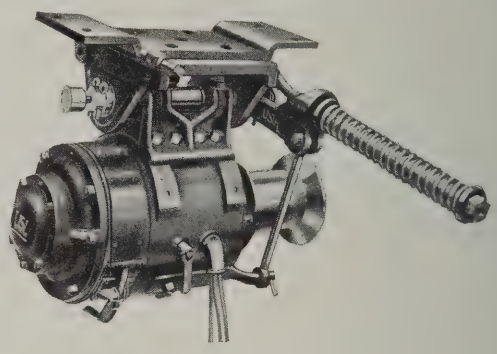


Fig. 5—Type "A" Generator with Body Suspension

Generator Suspension

On account of its simplicity, lightness and lower first cost, the body suspension is in common use with this Type 'A" equipment. The saddle casting which is bolted to the top of the generator frame in the body-hung generator is provided with two heavy supporting lugs, which are bored and fitted to the bushings to receive the supporting pin. This supporting pin likewise engages two depending lugs forming parts of the suspension bracket, which lugs are similarly machined and bushed and which straddle the lugs of the saddle. The suspension bracket consists of the two lugs mentioned and a horizontal portion cast integrally in steel. The top of the horizontal portion is designed in the form of a square, at the four corners of which are lugs cross tapped to receive set or adjusting screws. The suspension bracket is mounted against the suspension plate in such a manner that the four corner lugs of the former straddle the suspension plate. The bracket is secured to the plate by a central 1 in. stud threaded and riveted into the horizontal portion of the bracket. In addition there are four ⅞ in. bolts symmetrically located on a circle about the central stud. The plate is provided with five drilled holes for the stud and bolts while the bracket is provided with four slotted holes for the four bolts arranged on a circle concentric with the stud. See Fig. 5.

The suspension plate is generally made of ¾ in. by 8 in. steel plate and of length determined by the design

of the suspension layout. The plate is arranged parallel with the car or at right angles thereto and when parallel with the car is generally attached to supplementary angle irons or possibly to the transverse floor members. When arranged at right angles to the car, one end of the plate usually is attached to the center sill and the other end to the side sill of the car body. The set or adjusting screws which are threaded through the lugs on the corners of the suspension bracket impinge against the edges of the suspension plate and serve as adjusting screws to rotate the suspension bracket and generator about the central stud as a vertical axis, to secure exact parallelism of the car axle to the generator shaft. The saddle casting which is bolted to the top of the generator is always the same for any particular size or type of generator. The suspension plate is likewise, as already stated, universally made of ¾ in. by 8 in. steel plate. The suspension bracket necessarily varies in design to meet special conditions under cars of different types and construction. The top of the suspension bracket, the location of the corner lugs, location and size of central stud and surrounding bolts always remain the same. The supporting pin which engages the lugs of the saddle casting and those of the suspension bracket is always of the same diameter but varies in length with the size and type of generator and sometimes on account of the spread of the lugs of the supporting bracket.

Belt Tension Device

The belt tension device of the body-hung suspension is of a very simple design and construction. It consists essentially of an I-shaped casting, the end of the horizontal portion being bored out and bushed to fit the projecting end of the main supporting pin. It is located on the pulley side of the suspension. Its vertical portion constitutes a support for the standard spherical spring seat used on truck suspensions. This casting or tension lever, as it is called, is turned away from the truck and its outboard end is secured by means of a short pin-connected rod to a stud bolted to the generator frame just below the center. A stud is fastened into the pulley side of the suspension bracket on a line above the suspension pin and on the truck side thereof. A tension rod having an eye in one end and threaded for a distance of a foot or more on the other end passes through the vertical portion of the tension lever, its eye engaging the stud referred to. The spherical spring seat bushing is slipped over the free end of the tension rod and into place against the tension lever. The tension spring rests against the spring seat and is put under tension by means of standard gravity tension nut threaded onto the tension rod.

Pulley Alinement

At this point it is to be noted that body suspensions are designed wherever possible, so that the axle pulley, belt and generator pulley shall all lie in a vertical plane passing through the center of the car. In many instances, however, it is impossible to secure such an arrangement, but an effort is always made to locate the pulley as near the center vertical plane as possible, and if too great a diversion from this principle is permitted, unsatisfactory belt operation is sure to result.

It will be observed that the axle pulley of a body-hung generator has an unusually wide face, generally 10 in., and is provided with high, flaring flanges. The armature pulley also has similar flanges and its face is generally wider than that of the pulley of a truck mounted generator, but not as wide as that of the axle pulley employed with the body-hung generators. Generator pulleys with flared or straight flanges are interchangeable.

Constant Belt Tension

The tension on the belt is maintained by a very simple mechanism which preserves a substantially constant belt tension over a wide angle of swing of the generator from a vertical position to one in which the center of the shaft of the generator has been drawn by the belt some six inches toward the truck.

When the generator hangs vertically the only tension exerted upon the belt is that due to the action of the tension spring which tends to rotate the generator about the supporting pivot in a direction away from the truck. The moment arm of the tension spring or its leverage is the distance from the supporting pivot of the generator to the center line of the tension rod taken at right angles to the latter.

If the generator is swung toward the truck out of the perpendicular another force is added to the tension of the belt, namely, a certain portion of the weight of the generator, so that in this new position the belt tension is composed of or due to two forces: first, the tension of the spring; second, the weight factor of the generator. It will be observed that the further the generator is swung out of plumb the greater the weight factor becomes, but at the same time it will also be noted that the moment arm or leverage of the tension spring becomes rapidly shortened and therefore as the weight effect increases, the spring effect decreases. By properly choosing the strength of the spring, its initial tension, and correctly proportioning the parts of the tension mechanism, the net tension in the belt may be kept practically constant over the working range or swing of the generator.

It is obvious that when the center line of the tension rod passes exactly over the center of the pivot support, which is provided for by the hump or offset in said rod, the effect of the spring becomes zero and the weight factor is the only force producing tension in the belt.

If the center line of the tension rod should pass below the center of the pivot support of the generator the effect of the spring would reverse in its action and oppose the weight effect of the generator. Such a condition never obtains, however, but it is possible according to theory.

In practice it is customary to swing the generator shaft about 2½ in. out of plumb toward the axle and to cut and fasten the belt to hold the generator in this position. The tension is then set up to the required degree by compressing the tension spring until it is a specified length. The tension in the belt will then remain practically constant as the distance between the car axle and the generator varies due to the relative motion between the car body and truck, especially in going around curves and over switches, and the generator swings about its supporting pivot in accommodation to this motion.

It is for this reason that the initial stretching of a new belt causes practically no change in the tension, so that if the new belt is cut so as to draw the generator 2½ in. toward the truck, the only effect of the stretching is to allow the generator to swing back toward the vertical position, the belt tension remaining practically constant.

A Correction

In the June issue of the *Railway Electrical Engineer*, page 229, under the heading of Belt Fasteners, lines 3 and 4 should read,—

The Crescent belt fastener consists of one or more thin steel plates which are held in place by copper clad steel rivets.

Also the tabular data in this same column should be as follows:

CRESCENT RIVETS

Belt Size	Fastener	Large Shank
4″ 4 ply	No. 65	Twelve ½″ rivets.
4″ 5 “	“ 65	“ 9/16″ “
5″ 4 “	“ 87	Sixteen ½″ “
5″ 5 “	“ 87	“ 9/16″ “

Electrically Operated Air Compressors

Illinois Central Uses Automatically Controlled Apparatus to Pump Up Train Line Pressure

ELECTRICALLY operated air compressor units, used to pump up the train line pressure of freight trains in the yards, are installed or under construction at thirteen different terminals on the Illinois Central. As soon as the train is made up, the train line pressure is pumped up, an inspection and test is made to ascertain if all brakes apply and are in good working order before the locomotive is coupled to the train.

Having the train line under pressure, the train is ready to pull out as soon as the locomotive is coupled on, and brake test is made by locomotive thus eliminating from 20 minutes to an hour, terminal starting time. Ofttimes these extra minutes will allow the crew to get over the road in the specified eight hours and the elimination of a few hours overtime every day will soon pay for the compressor unit. Another point to be considered is that the dispatcher knows that the train is ready to go as soon as the locomotive is called and as a result he is able to time train movement to a better advantage.

Fig. 1—Exterior of the Compressor Building

A view of the building used for housing the three compressor units and electrical control apparatus, at Champaign, Ill., is shown in Fig. 1. Fig. 2 shows the interior of the compressor house. Note that plenty of room is allowed for the repairing and maintenance of the apparatus. Large air vents at each end of the building provide a circulation of air to help cool the interchange coil between the cylinders.

The Air Compressor

A closer view of one of the compressor units is shown in Fig. 3. The air compressors are two-stage, single acting, having two horizontal cylinders and two vertical cylinders. The motor drives the crank shaft of the pump by means of a herring-bone gear. This gear is mounted in the center of the crank shaft. A well, formed in the compressor frame immediately below the gear, furnishes

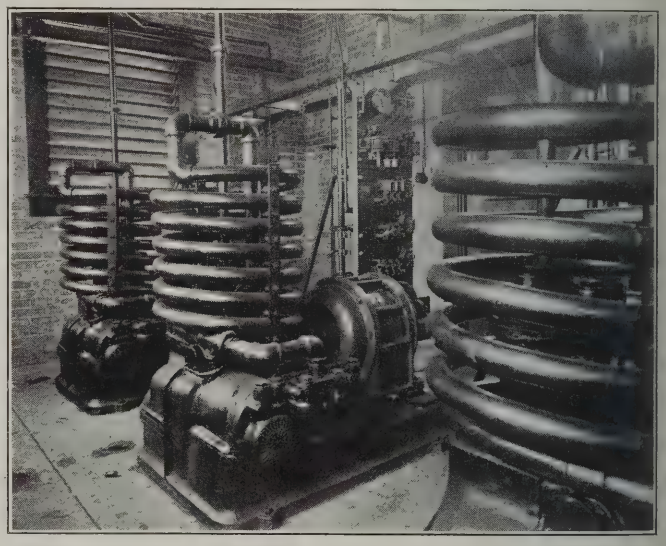


Fig. 2—Interior View of Building Showing Apparatus

an oil reservoir for automatically lubricating all working parts. The tubular type air valves are seated by gravity requiring no springs. The piston displacement is 125 cu. ft. per minute at 100 lb. pressure per sq. in. The intercooler between the high and low pressure cylinders consists of a coil of 2 in. pipe 30 ft. long. The motor is a 20 hp., 440-volt, 3 phase, 60 cycle, slip ring type, drawing about 30 amperes at full load.

Air Compressor Control

In order to maintain air pressure in the storage reservoir between specified limits, an automatic starting panel is used. Mounted on this panel are:

2 overload relays.

1 triple pole single throw lever switch; necessary contactors and relays.

1 pressure gage.

1 governor.

The governor is located at the bottom of the panel

and is essentially a single pole switch operated by means of a rubber diaphragm, a piston and a set of levers. The construction of this governor is such that the air does not pass through or come in contact with the operating mechanism, but is restricted to a chamber below the

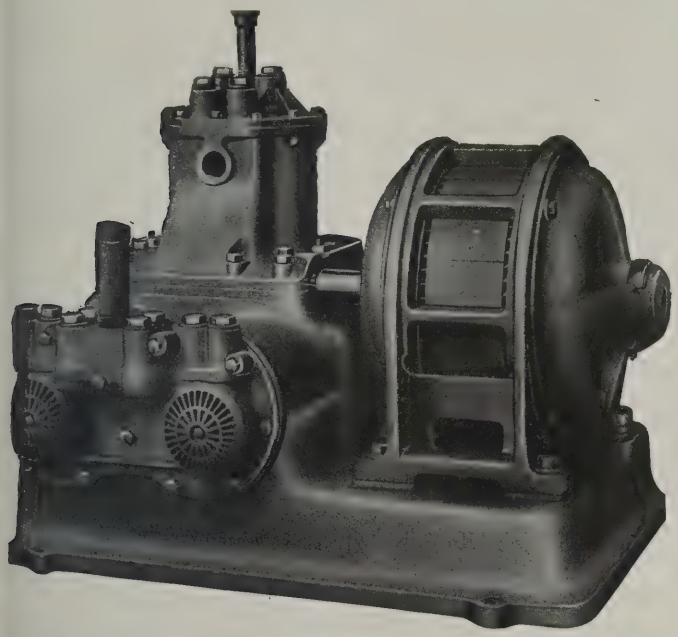


Fig. 3—A Closer View of One of the Compressor Units

diaphragm; hence troubles resulting from moisture due to condensation are said to be eliminated.

The operating mechanism is so arranged as to maintain constant pressure on the contact tips until the point

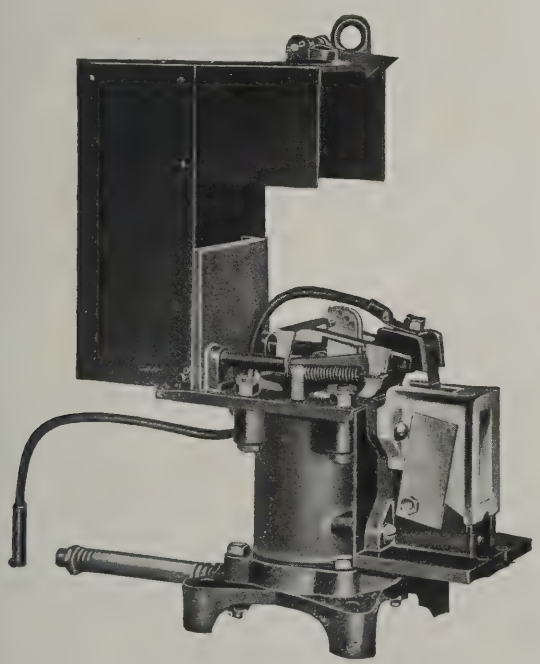


Fig. 4—The Air Actuated Switch or Governor

of tripping is reached. This construction ensures a quick break of the contacts when opening the circuit.

An accurate adjustment can be obtained by means of two adjusting screws which are conveniently located. The normal range of 10 lb. difference between the opening and closing pressures can be set for 8, 10, 12, and 15 lb. by changing the location of a pin in the fulcrum punching. The governors on the three compressor units are adjusted to cut in at different pressures ranging 2 lb. between each unit, so that only one motor would cut in for a slight reduction or to take up leakage; however, in case a train line is to be pumped up the pressure would drop down to, say, 50 lb., which would cut in all three units. All three governors are adjusted to cut out at 85 lb. pressure. The adjustments are changed from time to time so that different units will cut in first so as to equalize the wear on all units.

This governor is connected to the storage reservoir by a separate pipe connection. The closing of the governor contacts energizes the operating coil of the main contactor, Fig. 6, which in turn closes the circuits to the compressor motor at "A." With this connection the resistors R_1 to R_5, R_1 to R_6, R_1 to R_7, are connected across the slip rings of the motor. However, after a certain predeter-

Fig. 5

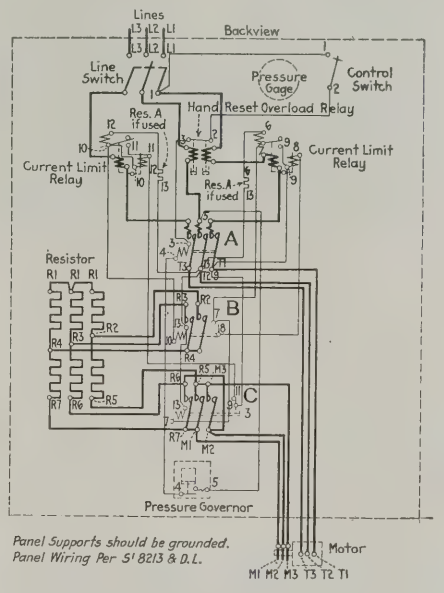


Fig. 6

Fig. 5—Front View of Control Panel
Fig. 6—Wiring of Control Panel

mined time, contactor "B" closes, shorting out half of this resistance. After the duration of another certain time, contactor "C" closes and the slip rings are then shorted, at which time the motor is up to speed.

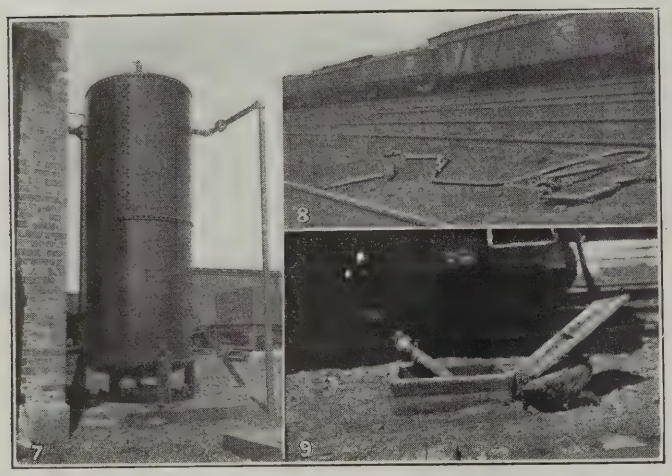
The overload relays protect the motor against excessive overloads either during starting or running periods and prevents the motor running single phase. The advantage of overload relays over any other form of protective device is that they can be set to open the control circuit at a smaller margin above the normal full load current while the time element of the relays will prevent opening the control circuit during the large current inrush at starting.

This type of control is used for the automatic starting and stopping of induction motor driven compressors where it is necessary to cut out the secondary resistance at starting in a series of balanced steps, giving equal fluctuations of current at each step, and thereby eliminating line disturbance which in many cases is objectionable, especially on lighting circuits.

Unloaders

Unloaders are used for all alternating current stationary air compressor sets to ensure reliability of operation under the conditions of power supply that are frequently met. The function of the unloader is to relieve the air compressor cylinders of pressure when the motor circuit is open in order that the compressor may be started against atmospheric pressure. To protect the unloader from pipe scale and other foreign material, a centrifugal dirt collector is installed in the discharge pipe near the unloader.

The working parts of the unloader are a combined lift



Figs. 7, 8 and 9—Air Storage Tank and Outlet Valves

valve and piston controlled by an electrically operated pilot valve. The lift valve prevents a back flow of air from the storage reservoir to the discharge pipe when the compressor is not running, and permits air to flow from the discharge pipe to the storage reservoir when the compressor is running.

When the circuits to the air compressor motor are closed, the operating coil of the pilot valve is energized and the pilot valve is closed, shutting off the connection between the discharge pipe and atmosphere. The increase of air pressure in the discharge pipe opens the lift valve in the unloader which establishes communication between the discharge pipe and the storage reservoir.

When the circuits to the air compressor motor are opened and the compressor is stopped, the operating coil of the pilot valve is deenergized. The pilot valve is opened causing the lift valve in the unloader to move to the closed position, shutting off communication between the storage reservoir and the discharge pipe. In the open position of the pilot valve, communication is established between the discharge pipe and atmosphere.

Fig. 7 shows a view of the air storage tank located near the compressor house, from which main pipes are run north and south. Another storage tank is located near the south end of the yard. From these tanks distributing lines are run under the tracks to outlet valves located in cast iron boxes between the tracks, as shown in Figs. 8 and 9.

Cost of Operation

As these compressor units are entirely automatic no attendant is required and a weekly inspection is sufficient to maintain the apparatus in proper condition. The three compressor units at Champaign were placed in service on March 11, and the cost of power since that time has averaged about $5 per day.

The air compressor units, motor and control apparatus was furnished by the General Electric Company and all construction work and installation was handled by the Illinois Central forces.

The Voluntary Relief Department, the company insurance plan of the Pennsylvania System, has announced amendments in the regulations pertaining to death benefits. Under the new rules, which went into effect June 1, the maximum death benefit has been increased and now ranges from $1,000 in the first class to $5,000 in the fifth class. The premium rates are very low, ranging from $14.40 annually per $1,000 of insurance for employees not over 45 years of age, to double that amount for employees over 60 years of age. These low rates are made possible by the fact that all operating expenses are paid by the railroad company.

Photo from Ewing Galloway

New York Central Yards at Toledo, Ohio

Electric Motor Drive for Machine Tools

A Discussion of the Relative Advantages of Different Types of Motors for the Operation of Machine Shop Equipment

By Gordon Fox
Electrical Engineer for Freyn Brassert & Co., Consulting Engineers, Chicago, Ill.

ELECTRIC motor drive enjoys well deserved popularity and is now almost universally employed for machine tool operation. There are many contributory reasons, the principal ones being:

Ease, flexibility and economy of electric transmission.

Freedom in the location of machines.

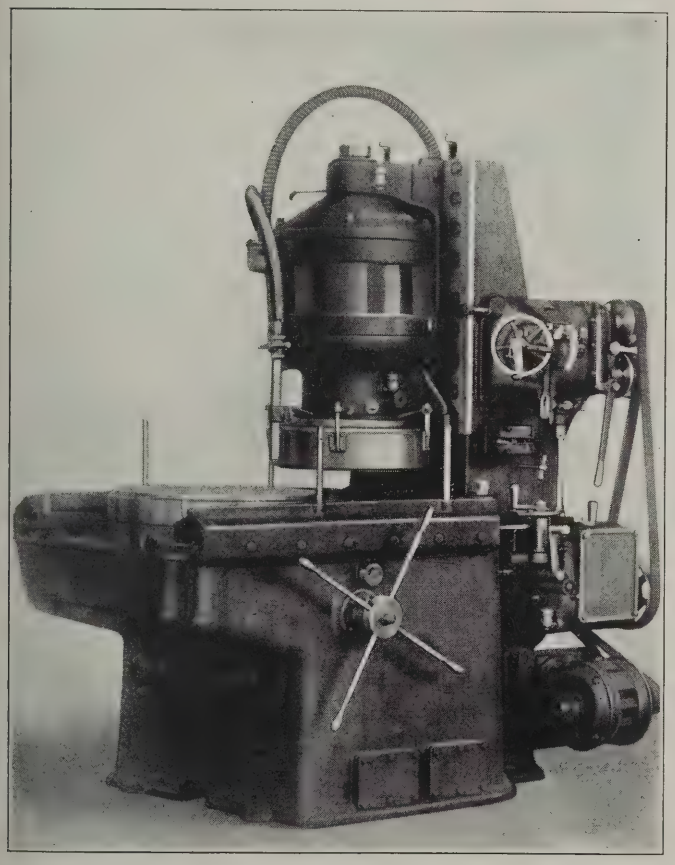
Reliability.

Possibilities for increased production due to controllability and speed maintenance.

Independence of machines.

Compact arrangement.

Machine tools vary widely in their functions. They



Surface Grinder With Vertical Motor Built In. Separate Motor Used for Raising and Lowering the Head

may be broadly classified, however, as rotary or reciprocating. The lathe, boring mill and drill press are examples of rotary machines, while the planer, shaper and slotter are examples of reciprocating machines.

The load demand upon a motor driving a rotary machine is made up of machine friction plus the power required to remove the metal. The relative values of these two items vary. The load demand of a reciprocating tool involves the above items and, in addition, the power required to start, stop and reverse the reciprocating parts due to their inertia. The load of a rotary machine may be quite constant, as in the case of a lathe making a continuous cut. If the cut is not continuous the load may fluctuate considerably. The load of a reciprocating machine is inherently of a fluctuating nature and the reversing peaks may be an important or determining factor.

Machine tool builders have compiled data as to power requirements of their machines. Similar information is available in handbooks. No effort will be made to set forth this data in these columns. It is proposed, however, to outline briefly, methods which are used in these determinations.

The frictional load of a machine tool depends upon its design and cannot be determined by formula. It may be best found by test.

The power required to remove metal depends upon the character of the metal, the type and condition of the tool and the cutting speed. The figures given in the table are widely used for lathes, shapers, boring mills and planers.

Power Required to Remove Metal

Material	Hp. to remove 1 cu. in. per min.
Brass	.2 to .25
Cast iron	.3 to .5
Wrought iron	.6
Mild steel .30 to .40 carbon	.6
Hard steel .30 to .40 carbon	1.00 to 1.25

The power required for drilling is about double that shown in table, due largely to friction between the drill and the side of the hole.

A number of empirical formulas have been developed for determining motor sizes for machine tools. The following are quite widely applied.

Power required by ordinary engine lathes
HP. = .15 S-1

Power required by heavy lathes
HP. = .24 S-2.
Where S = swing of lathe, in inches

Power required by standard boring mills
HP. = .25 S-4.
Where S = swing of mill, inches.

Power required by milling machines
HP. = .3 W.
Where W = distance between housings, inches.

Power required by sensitive drills
HP. = .06 S.

Power required for heavy radial drills
HP. = .1 S.
Where S = swing of drill, inches.

Power required by ordinary planer having two cutting tools and bed length about 2.5 times the width
HP. = 3 W.

For heavy forge planers
HP. = 5 W.
Where W = width of bed between housings.

All of the above figures are based on cutting tools of water hardened steel and cutting speeds of 15 to 20 feet per minute. If high speed tools are used, running at higher cutting speeds, the increase in power will be approximately proportional to the increase in speed.

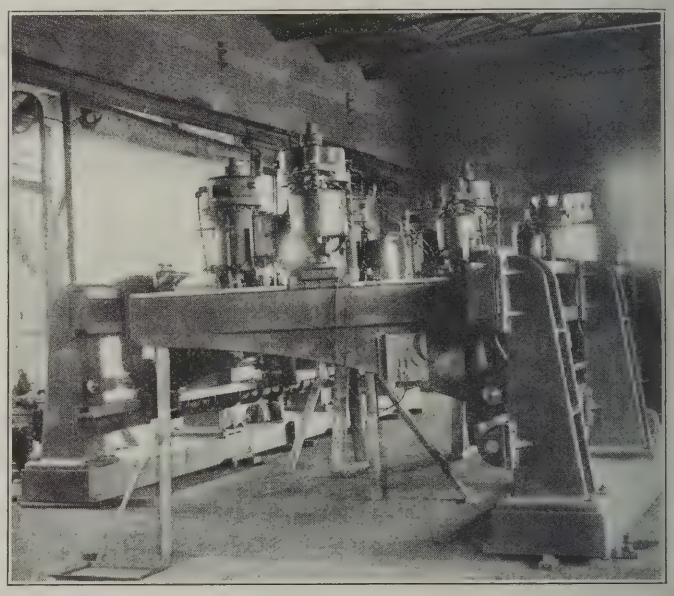
The requirements of machine tool service are such that several types of motors find application. A constant speed motor may be applied to any machine tool with some gain over constant speed belt drive from a line shaft. Adjustable speed motors are pre-eminently best suited to the majority of machine tools. Some machines, such as punches and shears, particularly when equipped with flywheels, require high starting and pull out torque together with slip under load. Here the compound wound direct current motor or high slip induction motor are well suited.

The adjustable speed direct current motor is excellently suited to the requirements of most machine tools. Due to varying diameters, materials and cuts, it is necessary to operate over a wide range of speeds. A selection of speeds can be had by the use of cone pulleys. A greater number is available by the use of a gear box. The adjustable speed motor provides a finely graduated selection of speeds over a range up to 4 to 1. If a wide range is desired, one set of change gears will suffice to double the range. The great advantage to be derived from the use of the adjustable speed direct current motor lies in the fact that maximum permissible cutting speeds may be maintained and speed may be readily manipulated. Where speed changes must be made in sizable increments it is necessary to use a speed lower than but approaching the desired rate. The margin represents a direct loss of production. Increased production has the double aspect of lower unit cost and less time required, lowering the overhead, facilitating good deliveries and quick repairs.

Due to the fact that alternating current is more commonly available, particularly in the smaller shops, the tendency has been for machine tool makers to include a gear box in his design and thus adapt his tool to induction motor drive. Such a machine is quite satisfactory and is well suited for many applications where direct current is not available and where conversion is not warranted by the advantages gained. There is, however, a tendency for machine tool builders to standardize these tools for constant speed direct current motors. From the viewpoint of the machine tool builder this is desirable in that the same tool may be applied to either direct or alternating current service. Where direct current is available, however, it will usually benefit the user to equip with the adjustable speed motors and eliminate the gear box.

It is not to be inferred that adjustable speed direct current motors should be universally applied. Wherever the speed control features are unnecessary and a constant speed is satisfactory the induction motor can be used to advantage. Records indicate induction motors to be somewhat more free from troubles and requiring less repairs than direct current motors. It is perfectly possible to have an equipment of direct current motors and control, if properly selected and applied and properly maintained, which will require few repairs. An induction motor, improperly applied or neglected, will stand up better than a direct current motor under like conditions. It must also be considered that more is usually expected of the direct current motor and control in the way of starting, stopping, reversing and speed control and the machine itself is thereby simplified and its maintenance and depreciation decreased.

In some cases both alternating and direct current are available. In some cases alternating current only or direct current only is available. In the latter case direct current motors will be used exclusively. In the case of a small shop where alternating current only is available, it will ordinarily be best to use constant speed induction motors, foregoing the advantages of adjustable speed to avoid conversion. For larger shops it may be advisable to install a converter or a motor generator to supply direct current for all or a portion of the machines. The use of both alternating current and direct current motors in the same shop may or may not be advisable. Where a number of large, constant speed drives are required, alternating current should be used if available even if a mixed installation results. If there are but a few constant speed drives, direct current motors may well be used for the sake of uniformity and to avoid two systems of current distribution. In some cases, direct current motors have advantages in controllability even for constant speed drives.

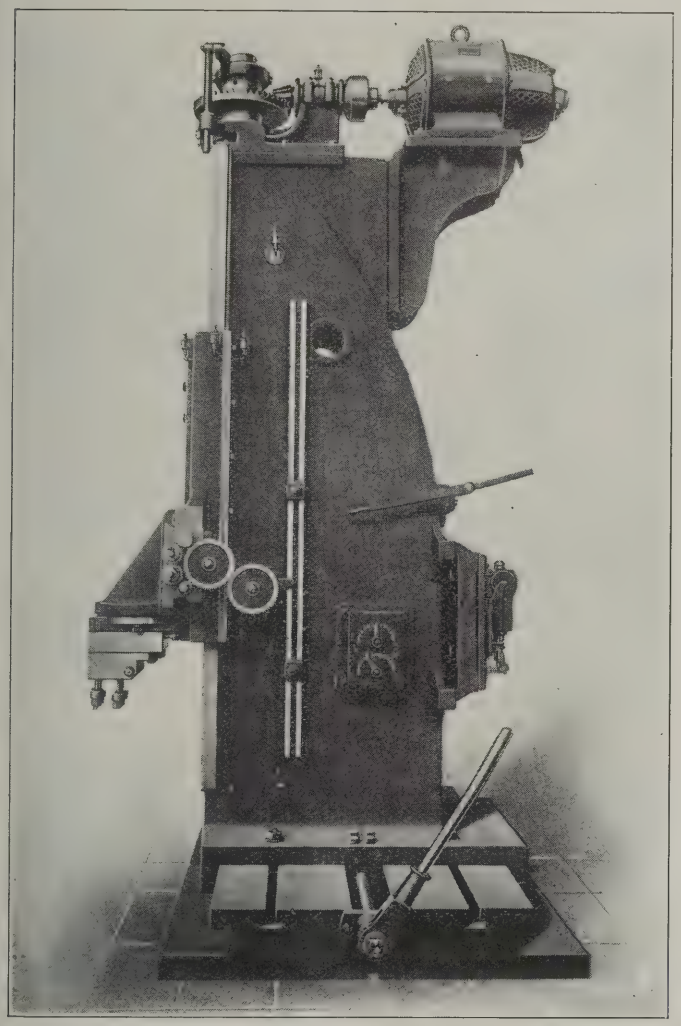


Boiler Plate Drill Machine With Motors Direct Geared to Drills

Machine tools may be driven by independent motors or several machines may be grouped and belt driven from a line shaft driven by a common motor. Both arrangements have their place. The tendency is toward individual drives, due largely to advantages in flexibility of location and operation and elimination of line shafting. Group drive enables the use of a lesser motor capacity having 25 to 75 per cent of the combined requirement of the driven machines, depending upon number of machines, relative sizes and diversity of operation. Group drive is particularly advantageous in this respect where fluctuating loads are involved as the fluctuations are relatively less as referred to the larger motor. Group drive is well suited for driving a number of small machines which are associated and naturally located together. Individual drive is particularly desirable where independent

controllability is desired, where adjustable speed is required, for machines rather widely scattered and for all large machines.

A rather important feature in the application of motors to machine tools is the question of location and connection of the motor. Motors should be well balanced to avoid vibration which hastens depreciation and may affect the finish of the work. Very high motor speeds should be avoided, particularly with direct current motors. The motor should be substantially mounted. The mounting arrangement should be possible for easy adaptation of a variety of makes and types of motors. This facilitates substitution in case of trouble. Lack of proper physical protection has contributed to many a motor failure. The motor should not be exposed to chips, dirt or oil. Totally enclosing covers on the upper half of the motor should be used for all except the least exposed installations.



Portable Slotter Designed for Motor Drive

Motors should be located where they will not be exposed to damage in the handling or transport of materials. These points are often neglected but are factors of importance.

There is a considerable trend toward incorporating the motor as an integral part of the machine tool. This practice has advantages in the matter of simplicity and effectiveness. It is complicated by the fact that most machine tool builders desire their designs to be easily adapted for either belt or motor drive. The design using the self contained motor is therefore somewhat special. It also has some disadvantage in that the motor also may be special in some degree.

Machine tools are quite commonly purchased equipped with motors and control. A shop containing a number of such machines may bear semblance to a museum in that a great variety of types of electrical apparatus will probably be represented. It is highly desirable that the variety of types and sizes of motors be restricted so that equipments may be interchangeable and a minimum of repair parts required. A shop of any size should have its purchases of electrical equipment supervised with a view to obtaining the most practical equipment both from an operating and maintenance viewpoint.

As controllability is one of the advantages of motor drive, the proper selection of control is important. Direct current motors may be provided with face plate type starting rheostats arranged for simple starting duty or including field adjustment. Such an equipment, if used, should be totally enclosed. Drum type control is preferable and is necessary if reversing or dynamic braking features are desired. The drum may include armature and field control points together with reverse, brake and drift points, if desired. Drum controllers do not protect the motor, nor is the starting resistance protected. The use of magnetic "push button" control is generally warranted and the details of such control should be carefully worked out to meet the peculiar requirements of the machine and to afford ample protection. Automatic starters are particularly desirable where frequent starting, stopping, reversing or manipulation is involved. For the sake of uniformity it will usually be found good practice to provide all direct current motors, except perhaps the very smallest, with magnetic control. With this type of control better protective features are possible. Simplicity and ruggedness are cardinal features. Where automatic control is employed, the panel should be totally enclosed for protection against dirt and tampering. The control may well be located at some point convenient for inspection apart from the machine tool. The operating master or push buttons should, of course, be located at the machine where most convenient to the operator. Control equipments and their component units should be duplicated so far as possible.

For starting squirrel cage induction motors manual auto starters are frequently used. Automatic starters are gaining in popularity. These may be of the auto transformer or primary resistance type. The starting torque of most machine tools is low, excepting flywheel type drives which have high torque squirrel cage or wound rotor motors. Wound rotor motors may be provided with either drum or magnetic control, the latter being necessary for such drives as reversing planers and tapping machines. Where there are a considerable number of squirrel cage motors installed in one shop, the use of one or two sets of transformers with partial voltage taps is suggested in conjunction with multi-voltage distribution and double throw oil switches or contactors for starting.

The full possibilities of electric control are often overlooked. Mechanical means are sometimes employed at greater expense and may be less effective where electrical control may accomplish the desired results in a better and cheaper manner. Control can be made to give quick

start, stop and reverse, smooth acceleration and slow down and fine speed adjustment and overload protection both to motor and driven machine. It may make possible the elimination of clutches, slip gears, speed reductions and shifts and other mechanisms.

In selecting an adjustable speed motor the fact should be considered that the speed range is determined by the rheostat resistance. It is not always necessary to utilize the full range of the motor rating. For instance a motor rated 400/1,600 r. p. m. may be operated from 400 to, say, 1,300 r. p. m. if the resistance is properly specified for that range. Care should be taken to avoid excessive or unsafe speeds by using too large a speed range. If the rheostat has too much resistance, the excess portion should be shorted out.

Having discussed, in a general way, the considerations involving the use of electric drive for machine tools we may consider briefly some various types of machines and their specific characteristics and requirements.

Lathes.—All lathes require some range of speed, the amount depending on whether the tool is used for a few simple operations or whether used for general work involving a wide range of diameters and materials. Lathes may require a speed range as high as 10 to 1. This can be obtained by an adjustable speed motor through use of one or more back gears. The use of constant speed motor drive, with gear box for speed adjustment, is quite satisfactory for the smaller sizes, particularly where the same type of work is repeated for long periods so that only occasional speed changes are necessary. Large engine lathes, wheel lathes and roll lathes are not well adapted to the use of change gears and the adjustable speed direct current motor is particularly advantageous. Wheel lathes should be provided with a slow speed point for use at hard spots on the wheel. With a direct current motor this is attained by shunting the armature with full field. If alternating current is used, a wound rotor motor may well be used and secondary resistance inserted to obtain the temporary slow down. When direct current is available the adjustable speed motor is almost always to be preferred for lathe drive. Control is ordinarily reversing and dynamic brake may be employed for a quick stop if desired. Lathes having a long bed are sometimes arranged so that the drum or master controller is driven from a handle on the apron of the lathe through suitable shafting and gears. This adds to the convenience of operation.

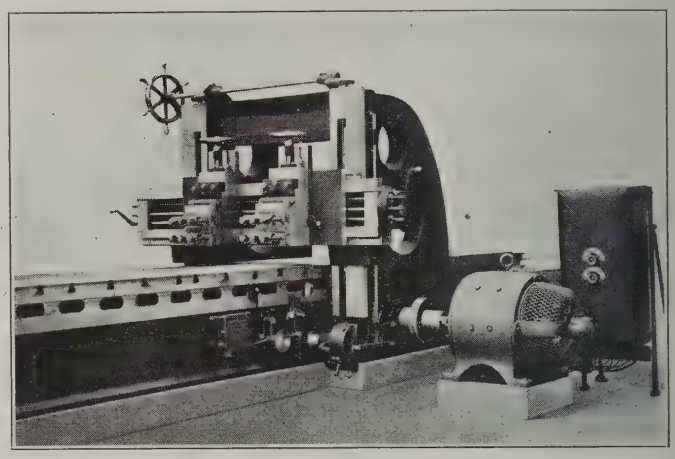
Boring Mill.—A variety of work is usually involved, requiring a range of speeds. An adjustable speed motor having a 3 to 1 or 4 to 1 range is the most advantageous installation. Constant speed motors may be used in conjunction with a gear box. The control for the smaller machines is non-reversing, but reversing provision is useful on large mills. For some mills it is desirable to provide a slow speed point with shunted armature. Magnetic control is preferable particularly on the larger mills.

Milling Machine.—Milling machines utilize a number of cutters of various diameters and render a range of speed adjustment necessary. The adjustable speed direct current motor is generally to be preferred.

Automatic Screw Machines.—The smaller machines may generally be driven by a constant speed motor or may be grouped. For the larger machines it is usually desirable to use an adjustable speed motor.

Drills.—Sensitive drills are usually provided with cone pulleys or gear box for speed adjustment although vertical motors are sometimes direct connected. Constant speed motors are generally satisfactory. The larger drills and radial drills may employ adjustable speed motor drive to advantage. The control is non-reversing on the smaller drills. Reversing control may be of advantage on the larger drives, eliminating a clutch. Where used for tapping, reversal may be obtained by reversing the motor. On alternating current, a wound rotor induction motor may be used with reversing control.

Grinders.—Constant speed motors are commonly used, being totally enclosed and having extended shafts to receive the grinding wheels. The use of adjustable speed



Planer Operated By Direct Connected 50 HP. Reversing D. C. Motor

direct current motors enables the most advantageous wheel speed to be maintained, as the wheel diameter is reduced by wear. Motors for grinder service require high pull out torque and liberal motoring is desirable, particularly for the smaller sizes.

Shapers.—The adjustable speed direct current motor having a wide range of speeds is commonly desired. Dynamic braking may be sometimes employed to obtain a quick stop. The control is ordinarily non-reversing.

Presses, Punches, Shears, Bull Dozers.—Machines of this class require high torques for short intervals. Flywheels are commonly employed. If direct current is used the motor should be compound wound. Induction motors may be of the squirrel cage type with high resistance rotor or, in the larger sizes, wound rotor motors may well be used and a fixed slip resistance employed. Machines of this character have high inertia. The motor should therefore have high starting torque and should be accelerated slowly. The control is non-reversing.

Planers.—Planers are variously equipped. The most simple drive is a constant speed motor provided with a flywheel, reversal being obtained by belt shifting with straight and crossed belts. A little more pretentious drive employs an adjustable speed motor applied in a similar manner. Two rheostats connected in parallel, may be used, one being alternately cut in and out by means of tumbler switches actuated by the platen. One rheostat governs the cutting speed, the other governs the return speed. Both speeds are thus independently adjustable. The speed range afforded is about 2 to 1. Drives of the above character are particularly well suited for the smaller planers.

Reversing drive for planers has been fully developed and has gained popularity. It affords independent control of cutting and return speeds. It provides fast and accurate reversal, eliminates belting, reduces delays and repairs and affords better control for setting up work. A special motor is used, having a small diameter armature of low inertia. The field is compound wound, with interpoles. Magnetic control is provided. The master switches are mounted on the bed of the planer and are tripped by movable dogs on the platen. The operator is provided with a start, stop and reverse switch independent of the master. Independent field rheostats are provided for adjusting the cutting and return speeds. The motor is generally arranged for a speed ratio of 4 to 1. There are two common methods of control. One provides simple plugging, the other introduces dynamic braking to decelerate the motor before reversing. The dynamic braking control gives smoother reversal but is slightly slower in reversing and somewhat less accurate. Accuracy in the point of reversal may be important where clearances are small. Some difficulty has been experienced with reversing planers due to overtravel, more particularly in the case of failure of power when nearing the point of reversal. The most effective preventive for this difficulty is a solenoid brake, on the motor shaft. This brake is shunt wound and is so connected that it is released at each reversal and is thus instantly effective in case of power failure.

Planers have been equipped to use a reversing motor in connection with a motor generator set and Ward Leonard control. However, this scheme is not commonly employed in the United States. Wound rotor induction motors equipped with magnetic control have also been applied to reversing drive of planers. For raising and lowering the cross rails of planers and boring mills and for moving the tail stocks of large lathes, special, heavily compound wound direct current motors are available. These are operated by reversing drum control. They are designed to develop high starting torque.

Slotters.—The operation of a slotter is similar to that of a planer except that the stroke is shorter. For crank operated slotters either a constant or adjustable speed direct current motor or a constant speed induction motor may be used, the constant speed drive being more common. Reversing drive, similar to planer practice is used, more particularly for gear slotters.

Bending and Straightening Rolls.—This is essentially a manipulating drive involving frequent starting, stopping and reversing. Direct current motors for this service should be heavily compounded and induction motors should be of the wound rotor type. Either drum type or magnetic control with master switch may be used, the latter being particularly preferable where the larger motors are involved.

The machines described cover but a portion of the machine tool field. In addition to other standard machines there are many special equipments. The same general principles apply throughout, with adaptations to particular needs. It is hoped that the foregoing discussion has suggested the general principles involved.

All Europe is planning use of water power to produce electricity according to Dr. Frank B. Jewett, Chief Engineer of the Western Electric Company, who has recently returned from a three months' trip abroad during which he visited most of the countries of Europe. In Switzerland, Italy, Norway, Sweden, Denmark and even in England detailed planes for development of natural water power for the electrification of railroads is under discussion. In the countries where there is a scarcity of coal hydro electrical development is of vital importance. In England the relative abundance of coal and absence of any considerable water power gives a somewhat different trend to the problem. There is talk of combining the natural resources of Norway, Sweden and Denmark. Norway has enormous natural water resources, Sweden not so much, and Denmark very little. The current would have to be carried by submarine cable in many cases, and this fact presents some interesting engineering difficulties. The immediate difficulty in carrying out these extensive developments is the financial situation, and it is probable, therefore, that little will be done until the currency has recovered somewhat from the present depreciation.

Photo from Ewing Galloway

A Cotton Warehouse Yard

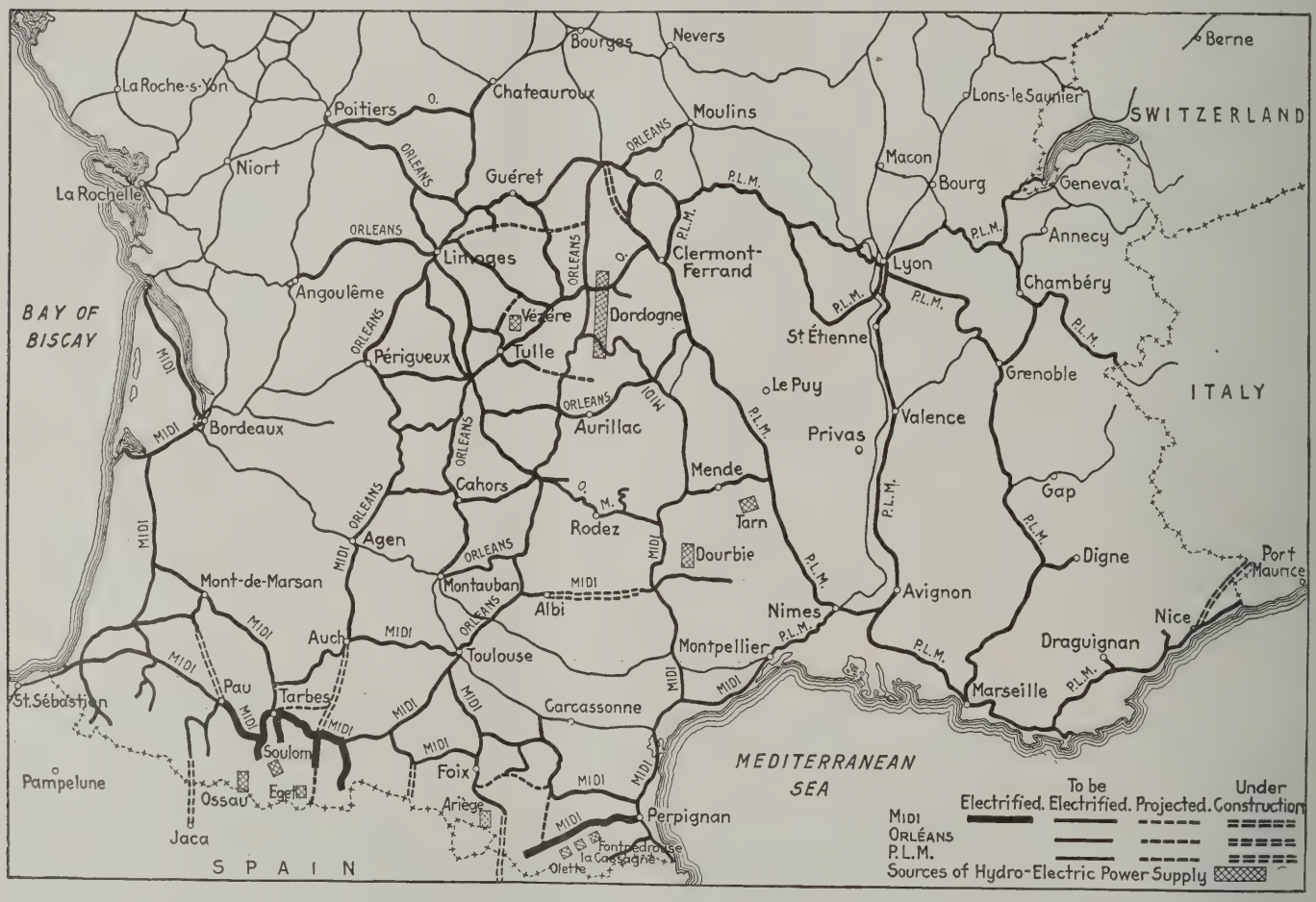
Electrification of French Railway Systems

Huge Program to be Spread Over Period of Years Ultimately Extending to All Lines in Southern Section

By Oliver F. Allen
Formerly Major of Engineers, American Expeditionary Forces

THE electrification of French steam railway lines, as distinguished from street car or interurban service as those terms are understood in America, began by the equipment about 1900, and almost simultaneously, of the tunnel and connecting tracks between Quai d'Orsay station and the Austerlitz station of the Paris-Orleans Railway in Paris with an extension for suburban service as far as Juvisy and the suburban line from the Invalides station in Paris to Versailles on the old Western Railway, both of these early Paris electrifications has always been supplied by steam plants burning coal. The other two early electrifications, in the French Alps and in the Pyrenees, were made to meet the requirements of mountain grades and to take advantage of water power. These first installations are all still in service, and the further extension of three of them are the first steps in the present program.

The successful operation of these early installations,



Southern France, Showing Lines to Be Electrified

now known as the State Railways. A division from Fayet to Chamnoix on the Paris-Lyons-Mediterranean line was electrified about 1902, and one on the Southern Railway, in the Pyrenees, from Villefranche to Vernet-les-Bains by 1910. The two electrifications at Paris radiating out from the centers of the city, were made for the purpose of increasing terminal facilities, improving suburban service and removing the smoke nuisance. They were of the same general order as the early electrifications in America at the New York City terminals and the Baltimore & Ohio tunnel at Baltimore. Current for both of these early Paris electrifications has always been supplied by steam plants burning coal.

The other two early electrifications, in the French Alps and in the Pyrenees, were made to meet the requirements of mountain grades and to take advantage of water power. These first installations are all still in service, and the further extension of three of them are the first steps in the present program.

The successful operation of these early installations, the facility with which they took care of increased traffic with a moderate increase in investment, combined with the successful development of electric traction in America and elsewhere, led the French railway engineers to study, before the war, the problem of reducing their coal bill by the electrification of their main lines.

The electrification of the lines from Limoges to Gannat and from Clermont-Ferrand to Tulle and the development of steam power stations in the central plateau, the Massif Central, where coal is to be found, was studied by the engineers of the Paris-Orleans before the war.

The electrification of the mountain divisions of the Paris, Lyons & Mediterranean Railway northeast from the French terminal of the Mt. Cenis tunnel at Modane and of more Southern Railway lines in the Pyrenees was all carefully studied before 1913. During the two years preceding the war, the Southern Railway had completed preliminary negotiations for electric locomotives and had placed firm orders for samples.

It is apparent that irrespective of the great economic changes resulting from the war, especially in the matter of cost of coal and labor, the electrification of the French railways would have gone ahead under pre-war conditions and it is possible that had France not been set back five years by the war, a considerable portion of the present program would be an accomplished fact today.

As soon as mobilization began in the last days of July, 1914, the entire resources of the French railways were placed at the disposal of the government, and from then until after the armistice all the railways were operated as a unified command under the fourth section of the general staff of the French army. Under war conditions no attention was paid to the matter of electrification.

The Reconstruction Program

The undreamed of increases in the cost of coal and the diminution of personnel, combined with the eight-hour day movement, forced the study of reconstruction and after-the-war railway economic problems while we were all still fighting the Boches. This study was so far advanced that three days after the armistice, that is, on November 14, 1918, a committee was formed by a decree of the Ministry of Public Works for the study of the electrification of the standard gage steam railways. Within two weeks, November 23, 1918, this committee was organized and a program adopted for the study of the electrical operation of railroads all over the world, particular attention to be paid to what had been accomplished in America, France, Switzerland, Italy, England, Sweden and Germany. The visit of representatives of this committee to the United States in 1919, and their exhaustive reports on electrification in this country as well as in Europe have been published and are so well known to railway engineers that further reference will not be made to this committee's work except to point out a few important results which might be advantageously considered by American railways.

Equipment for All Lines to Be Standardized

Realizing that successful electric traction must be as flexible and as universal in its application as steam traction, the French concluded that all their main line electrifications must be standardized to such an extent that the electric locomotives of any company can circulate on all the lines in France just as easily as steam locomotives can. This involves agreement by all of the railways to use electric current of the same characteristics. That decision has been made by the railways and approved by the Ministry of Public Works and the Ministry of War. It standardizes 1,500 volts continuous current for all French railways. Incidentally it is interesting to note that this French action has been followed by the adoption of the same standard for Belgium and for England.

Trolley and Third-Rail Collection

The voltage selected permits the use of either overhead trolley wires or third-rail for delivering the current to the locomotive and it is probable that both will be used according to local conditions and the relative cost. Irrespective of the exact method of suspension of overhead wire or of support or type of third-rail which may be used by any particular railway, standardization will be carried to such a point that the pantagraphs and contact shoes of all the locomotives will be so designed and located that they can collect current on any electrified line in the whole country.

The investigations showed so plainly the restrictions on the development of electric traction resulting from lack of standardization in other countries, especially in America, that the French railways and government very soon realized the necessity for an organization to study and make effective standardization work begun by the decision to use only one kind of current. Something over a year ago the State Railways, the Southern Railway, the Paris, Lyons & Mediterranean Railway, the Paris-Orléans Railway and the railways of Alsace and Lorraine, with the co-operation of the Ministry of Public Works, created an organization for the study of railway material known as l'Office Central d'Etudes de Material de Chemins de Fer. It will be noted that the Northern and Eastern Railway systems are not included in this group. It was felt that their problems of reconstruction were so difficult that they should be left entirely free to restore service by any means available. Parts of their lines which were not destroyed were subjected to the most intensive traffic possible by the requirements of the French and American armies.

Frontier Development Must Provide for Military Factors

Another aspect of the matter is the military situation and the realization that along the frontier it must always be possible not only to mobilize an army quickly but to move it and its supplies across the frontier rapidly and efficiently. If the railway lines near the frontier were equipped for electric traction, it might be possible to mobilize as rapidly as with steam locomotives, but getting an army across the frontier would be another matter. There is some doubt about the relative reliability of the necessary interconnected generating stations, distributing stations, transmission lines, etc., for electric locomotives and the supply of water and fuel for steam locomotives, when subjected to the hazards of long range shelling and airplane bombing. This question is still so far from being decided that the electrification of the railways of the north and east of France is not contemplated now.

Immediate Development Will Be Limited to Terminals and Suburban Lines

While the State Railways are in the group which created this standardization committee their electrification for many years to come will probably be confined to terminals and extension of suburban service in the immediate vicinity of Paris. The major portion of their lines as well as the lines of the Northern and Eastern Railways cover territory in which there are not only no large water powers available but in much of which the amount of condensing water to be had is so limited to curtail seriously the construction of very large power plants. It is probable that in those parts of France north of a line running southwest from Paris to the Atlantic Ocean at St. Nazaire, and those between Paris and the Belgian and Luxem-

bourg frontiers, the railways will not be equipped for electric traction until electric power may be available either from the Rhine or the Alps, nor until the electrification of the other parts is largely completed. In view of the demands for power in the neighborhood of Paris and between Paris and the German and Swiss frontiers, all electric energy which may be available within the next twenty years will probably be utilized before it gets to the north and northwest, or for the metallurgical and other industrial plants in the north and east where needs for electric power are economically more urgent than those of the railways.

Effects of High Cost of Fuel and Labor

This standarization committee of the principal railways outside of the north and east is working for general standardization and in many aspects of its work, through the Ministry of Public Works and the close affiliation of all the railway executives and engineers, it will affect all of the railways, including the north and east. So far as its practical application to electrification is concerned its work will be confined for a long time to the railways which made their first electrification twenty years ago and the railways in the recovered provinces of Alsace and Lorraine. In fact, the men who are most active today in carrying on the French railway electrification program are the very men who personally had to do with the four original installations referred to above.

The electrification of the French steam railways is not a new proposition resulting from the war, but is the natural and logical evolution of those first applications at terminals and in mountains almost a generation ago. It is true that the war has brought about certain economic changes, particularly in the cost of fuel and labor, which will tend to expedite the change from steam to electric power. For instance, the cost of coal before the war was from $3.85 to $5.80 per metric ton and since the war reached the maximum in 1920 of $51.60 per ton with a peak of $86.00, which is the price actually paid by one railway for part of its coal. It is now descending to between $16.30 and $24.50 per ton. There is little likelihood, however, of coal going to less than about $12.25 per metric ton, that is, three to four times pre-war price, for many years to come. On the other hand, the tremendous increase of the public debt in France and the general economic losses resulting from five years of war tend to retard the expenditure of the vast sums of money required for extensive electrification and it is doubtful if the urgency of the high fuel cost and the labor situation is not so far offset by the financial situation as to make the carrying out of the program move slower rather than faster than it would have had there been no war. Our French friends seem to have taken the lead in the world in standardizing and adopting electric traction for steam railways, and in spite of the delays and embarrassments resulting from the war they may still go ahead faster than we will in this country, particularly in the matter of high speed passenger service.

Reasons for Electrification

Their reasons for electrification are substantially the same as influenced similar decisions elsewhere and are too well known by railroad men to be discussed in detail here. The determining factors are: first, utilization of water power to reduce the amount of coal imported into France each year and to reduce operating expenses; second, the ability to increase terminal facilities and improve terminal service by substitution of motor cars for suburban service and electric locomotives for main line passenger trains and freight service; third, the ability to handle heavier freight trains and move greater tonnage on mountain divisions than is possible with steam locomotives without great expense for enlarging tunnels, strengthening bridges, and other items of increasing the number of tracks. There are many other reasons which have affected the decision to start a comprehensive program of electrification, but they are more or less subsidiary to these main considerations.

Program Calls for 1,200 Miles of Main Line Each Year

The program, the execution of which is being seriously undertaken, involves electrification within the next fifteen years of approximately 6,000 miles of main lines mostly already double track and the building of hydro-electric plants and high tension transmission lines of the first magnitude. French engineers have gone so far as to promulgate a tentative program involving electrification of over 1,200 miles of main line per year and putting into service of not less than 400 new electric locomotives every year. Financial considerations will probably greatly curtail such a program, but the more conservative one of the electrification of 6,000 miles within fifteen years will involve buying between 200 and 300 new electric locomotives per year, which is a bigger project than has yet been undertaken in any other country.

Power Supply

The hydro-electric developments to furnish the necessary power will be carried on simultaneously in the Pyrenees for the lines of the Southern Railway; on the central plateau for the Paris-Orleans Railway and in the French Alps for the Paris, Lyons & Mediterranean Railway. These are being studied in connection with the development of a great network of power transmission for industrial requirements. Under the leadership of the Ministry of Public Works a program has been prepared for a transmission network at 220,000 volts for the main lines and 100,000 to 150,000 volts for the secondary lines which will cover all the northern, eastern, central, southern and southwestern part of the country with great trunk lines from the upper Rhone valley and from the Rhine valley in Alsace in long loops across the country to Paris.

The first plants and transmission lines will be built partly by private organizations, including some of the railways, and partly by the government. Some of the 100,000 and 150,000 volts lines are now under construction and the first additional hydraulic plants with a total capacity of the order of 300,000 horsepower may be under construction within a year.

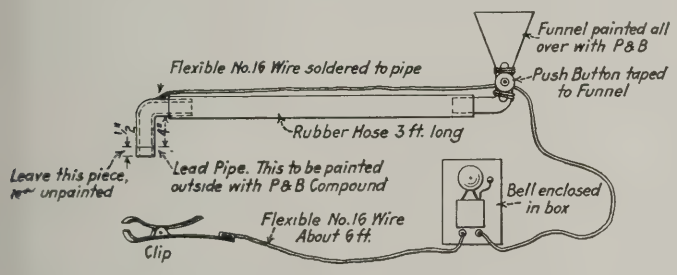
Belgium

In Belgium the program covers several of the lines which converge at Brussels. The first step will be to take care of the intensive passenger traffic between Brussels and Antwerp. The next, the freight traffic in the metallurgical district where there are steep grades and great tonnage. The rapid fall in the price of coal (that mined locally plus that shipped in from Germany has already accumulated until Belgian stocks on hand present a serious problem) combined with the delay in getting any reparation payments from the always delaying Germans has set back the Belgian electrification program indefinitely.

Cell Flushing Device

By A. H. Matthews

Not only is it a fault to have too little water in a cell, but it is also a fault to have too much water. Some cells are arranged with floats, while others do not have them. There are flushing devices on the market but every yard man does not feel that he can afford to buy them. However, if a man is interested in securing a handy device for


Funnel painted all over with P&B
Flexible No.16 Wire soldered to pipe
Push Button taped to Funnel
Rubber Hose 3 ft. long
Leave this piece, unpainted
Lead Pipe. This to be painted outside with P&B Compound
Bell enclosed in box
Flexible No.16 Wire About 6 ft.
Clip

Sketch Showing Details of Flushing Device

flushing cells, he can readily make this little time saver, shown in the sketch.

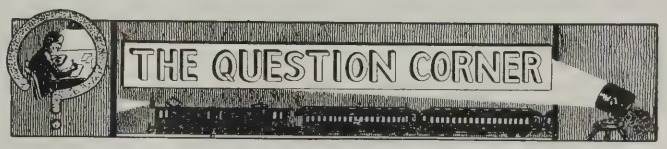
To use the device the clip is connected to a lug on the cell furthest away from the one being flushed. The push button is held closed by the fingers so that the circuit will be completed as soon as the liquid rises to the proper height in the cells. The push button, however, is really not essential and the wire could just as well be continuous. For filling, a quart dipper painted with P & B compound has been found most convenient.

Sparks Caused by Loose Bars

The small sparks which are sometimes noted between the rotor and stator of induction motors are caused by the slot bars becoming loosened from the copper short-circuiting rings, according to a writer in the *Electrical World*. The only remedy is to solder or weld the rings tightly to the slot bars. If not attended to, the stator winding is liable to become punctured. With a rotor of any size, say 25 horsepower, the heat for such a repair job must be supplied by a gas flame with air pressure.

The Bothersome Clinker

A clinker in the firebox of an engine helps to subdue the fire. Some men have clinkers in their brains which help to subdue their chances in life.



Answers to Last Month's Questions

1. *Give some reliable test that will show whether or not electrolyte contains iron.*

2. *What percentage of iron in electrolyte would you consider injurious enough to prohibit the use of the electrolyte again?—R. Y.*

* * *

The answers received for the questions which appeared in the July issue show that there is a very lively interest taken in the subject of electrolyte for storage batteries. Some of those which follow are from users of storage batteries, while others are the condensed opinions of some of the storage battery manufacturers. Certainly the one who asks these questions should be able to find some information of value to him among the answers presented.

While we are on the subject of questions and answers, it might be well to bear in mind that while there are plenty of answers forthcoming, there seems to be relatively few questions. Let's have some more of them.

* * *

I submit the following answers to the July questions:

1. Test for iron. Neutralize a sample of the electrolyte with ammonia; boil a small portion with hydrogen peroxide, and add ammonia or caustic potash solution until the mixture becomes alkaline. If a brownish red precipitate forms, it indicates iron.

2. If iron is found to be in the electrolyte in any quantity, it is best to use new electrolyte. A. H. M.

* * *

Substantially the same answer as was given in No. 1 above is also given by R. C. F. E.

* * *

The following table shows the percentage of impurities which should not be exceeded in storage battery electrolyte:

Arsenic	Trace
Manganese	Trace
Iron	0.003%
Chlorine	0.001%
Nitrogen, any form	0.01%
Copper	0.002%
Sulphurous acid	None
Organic matter	None

The usual test for iron in electrolyte is as follows:—

Commercial acid to be mixed with an equal volume of a 5 per cent solution of ammonia sulphocyanide, which can be obtained from druggists and should be made as follows: Ammonia sulphocyanate cryst, 1 oz.; water, 2 oz.

If iron is present the solution will turn a red color, the shade of same being dependent upon the percentage of iron in the solution. This should be compared with two sealed test tubes, one containing electrolyte with .01 per cent of iron and equal portion of reagent and one containing electrolyte with .005 per cent of iron and equal portion of reagent. Of the sealed test tubes, that having the .01 per cent of iron will be the darker color and if the color of the acid and reagent under test is darker in color than this, the acid should not be used.

C. S.

* * *

Practically all electrolyte contains a certain amount of iron, and if the amount is not permitted to exceed a certain limit, it will not prove injurious to the battery.

The simplest test for iron solution is to add a few drops of a solution of potassium sulphocyanide and the presence of iron will be indicated by a blue color which will be deeper the greater the amount of iron. This test is very delicate, and will show quite a strong color in nearly any sample of electrolyte. It is, therefore, of little use except in the hands of an expert who can judge from the depth of the color whether the amount of iron is excessive or not.

A quantitative determination is the only sure guide and this is best shown by a colorimetric method, which is hardly practicable outside of a laboratory. In this test, a small sample of the electrolyte to be tested is first oxidized with weak potassium permanganate solution and a measured quantity of ammonium sulphocyanate solution added and made up to measured volume in special glass color tube. The same amount of commercially pure acid is treated in exactly the same way and standard iron solution added to the latter drop by drop until the two colors exactly match. The amount of iron is then calculated from the amount of standard iron solution used.

Iron in electrolyte, in excess of fifteen grams per 100 liters, is liable to cause trouble. However, in using acid over again in a new cell, it must be borne in mind that a certain amount of iron is liable to be introduced into the cell while in service, either in the water which is used for filling it, or in the dirt and dust which sometimes finds its way through the vent opening. Furthermore, it is sometimes true that a certain quantity of some one impurity will do no harm in the absence of other impurities, whereas if other impurities are present, the amount of the first impurity must be reduced.

Generally speaking it is best to send samples of the electrolyte to the battery manufacturers for test, which is usually done without charge. Tests that are made by unskilled persons are very liable to lead to the wrong conclusions.

L. J. W.

* * *

1. Electrolyte always contains iron and this impurity has in the past, particularly in text books, been given undue importance. The main objection to its presence in a cell is on account of the fact that iron sulphate exists in ferrous and ferric forms, the ferrous being convertible to ferric at the positive and the ferric being reconverted to ferrous at the negative, with the result that the continual movement of ions from one plate to the other gradually causes the cell to lose its charge. Of course, to cells which are in daily use the presence of a small quantity of iron merely produces a minute loss in efficiency, and it is only in cases when the cells are allowed to stand for several weeks that any evil effects result. With regard to a test for iron, a few ccs. of the electrolyte may be taken in a test tube, one drop of nitric acid added and boiled. On cooling, a few ccs. of ammonium sulphocyanide are added and a red color is produced, the color being proportionate to the amount of iron present.

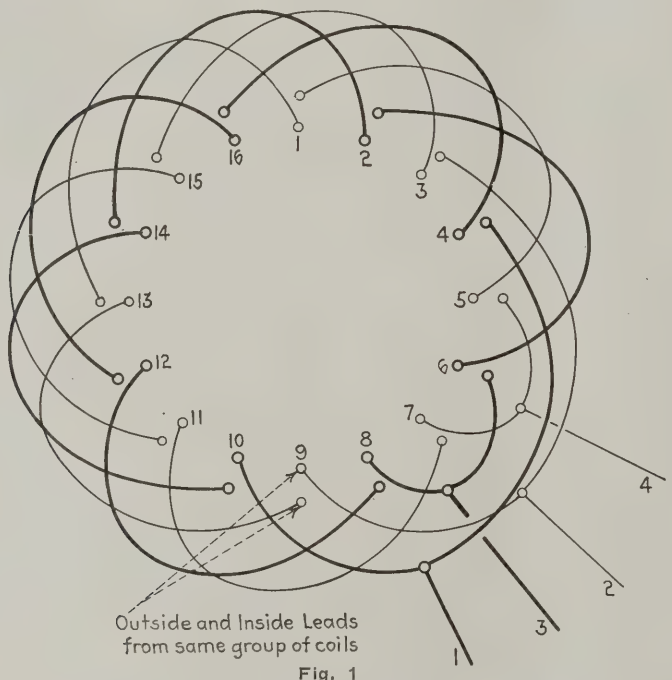


Fig. 1

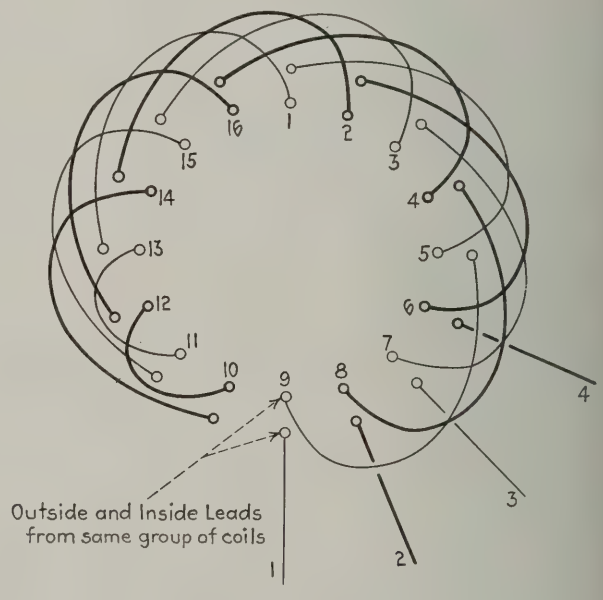


Fig. 2

Fig. 1—Diagram of Original Connections of Motor Operating on 220-volt Circuit
Fig. 2—Diagram of Connections After Changing to 440-volt Operation

2. The writer has frequently come across batteries in which the iron ran as high as .5 gm. per litre, without any bad effects being observed, but as the presence of iron is usually indicative of the fact that the cell electrolyte has been contaminated it is recommended that a charge be made when the amount present has reached .1 gm. per litre, when iron was low in new cells.

H. D. R.

* * *

The Motor Question

In the June Question Corner a question was asked with relation to changing the operation of an induction motor from 220 volts to 440 volts. At the time of going to press last month some information had been gathered concerning this problem but it was not considered complete enough to publish and therefore it was held out until this issue when we are able to give a more complete explanation. The exact question was as follows:—

Can you give any information regarding the reconnecting of a 220 volt, two-phase, four wire, 60 cycle induction motor so that it can be used on 440 volts of the same frequency?

In condensed form the information required by the author of the question might be summed up as follows: The motor uses 48 coils; one 1-6; coils in groups of 3 in series. For 220 volt operation, the groups were connected two circuit as shown on the diagram, Fig. 1. For 440 volt operation, the groups should be reconnected one circuit as shown on the diagram, Fig. 2.

While this information may be entirely clear to those who are familiar with the winding of induction motors it may not be entirely satisfactory to all of the readers of the Question Corner who have been awaiting the solution of this problem. For this reason a little longer and more simplified explanation seems to be in order. The motor in question has 48 slots, with one coil per slot, that is one-half of one coil lies in the same slot with one-half of another coil, the winding being the customary lap winding. Three coils are connected in series, and the 16 groups of coils resulting are connected in four separate circuits, each circuit consisting of four groups in series. For the 220 volt connection, two of these circuits are connected in multiple to each phase; for the 440 volt connection eight coils are connected in series across each phase; however, in changing from the 220 to the 440 volt connection, the coils are not connected in series in the same order in which they were formerly connected in separate groups. More complete wiring diagrams are shown in Figs. 3 and 4, Fig. 3 showing the winding of Fig. 1 and Fig. 4 corresponding to the winding of Fig. 2. In these complete wiring diagrams the connections may be more easily traced. The left-hand terminal of each group of three coils corresponds to the terminals forming the inner circle shown in Figs. 1 and 2, and the right-hand terminals of the coils correspond to the terminals forming the outer circle.

In showing the connections for 440 volts, the 220 volt connections have been indicated by dotted lines and the connections which have to be made are indicated by dot and dash lines. This has been done in order to show the difference in the connections with the least amount of confusion. The diagrams really show that quite a number of connections will not have to be changed at all.

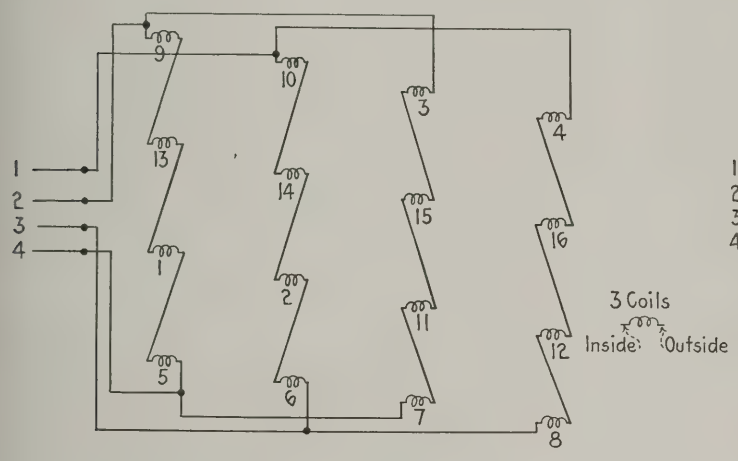


Fig. 3

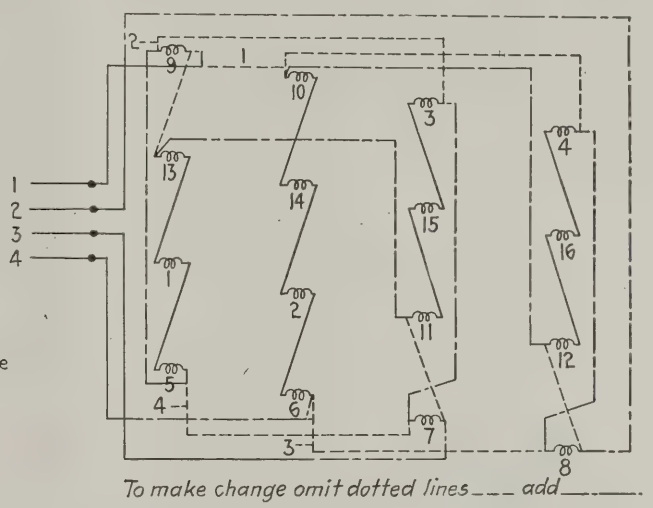


Fig. 4

Fig. 3—Complete Wiring Diagram Corresponding to Fig. 1
Fig. 4—Complete Wiring Diagram Corresponding to Fig. 2

In making the change the following connections will have to be broken and made:

Terminals	Break	Connect
Outside 9	Inside 9....Outside 3	Inside 9....Outside 5
Outside 8	Inside 8....Outside 6	Inside 8....Outside 4
Outside 7	Inside 7....Outside 5	Inside 7....Outside 3
Outside 6	Inside 13....Outside 9	Inside 13....Inside 11
	Inside 12....Outside 8	Inside 12....Inside 10
	Inside 11....Outside 7	
	Inside 10....Outside 4	

It is suggested that the man who winds this motor trace the four leads with the various coils and that when he has determined the arrangement that he may mark these numbers on the coils with chalk.

* * *

Questions for August

1. *I would like to have explained the difference between a reactance coil having an iron core and one without such core.*

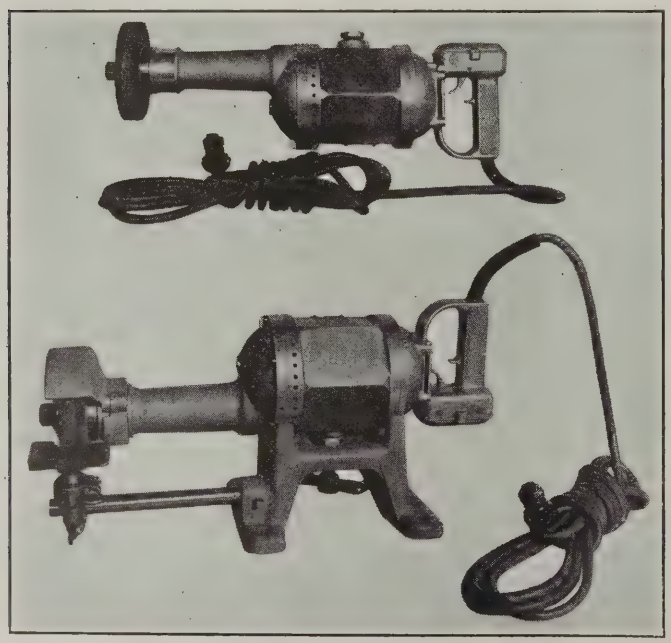
2. *If magnetism can not be insulated or screened why is it that a brass or copper tube slipped over the iron core of an induction coil cuts down the voltage at the secondary terminals?*

B. R. E.

NEW DEVICES

A Portable Electric Grinder

A portable electric grinder has been recently placed on the market by The Black & Decker Manufacturing Company, Baltimore, Md. As may be seen from the photograph, the new grinder is equipped with a pistol grip and trigger switch. The motor used in this outfit has a capacity of one-half hp. and operates at a speed of 3,200 r. p. m. The size of the grinding wheel is 5 in. in diameter by 1 in. in width, being mounted on an arbor with a diameter of ¾ in. The net weight of the tool, without

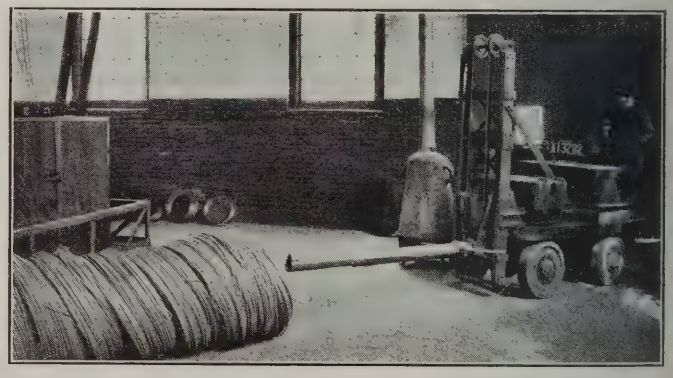


Grinder May Be Carried About or Used With Base as Shown

the base, is 21 lb. Although this electric grinder is essentially a portable tool, it is supplied with a detachable base and adjustable tool rest so it can be used with equal facility as a bench grinder. Besides the base the equipment also includes two 5 in. by 1 in. grinding wheels, one fine and one coarse, a wire brush wheel and a rag buffing wheel. With this complete outfit it is practically possible to accomplish any grinding, cleaning, buffing or polishing jobs that may be met with in machine shop or foundry. The number of jobs that can be done with such a grinding machine is practically limitless. This grinder is exceptionally light, the gears and shafts being made of chrome nickel steel and the housing of aluminum alloy. Grease lubrication is used throughout and the temperature of the motor is kept down by forced air cooling. A desirable feature is the fact that the grinders can be operated on either direct or alternating current.

Electric Truck With Carrying Ram

The illustration shows an electric storage battery truck made by the Baker R & L Company, Cleveland, Ohio, the truck having been recently equipped with a carrying arm or ram which may be elevated or lowered as desired. This feature of the truck was originally developed to enable it to handle the large numbers of heavy iron cores



Baker Truck Equipped with an Elevating, Carrying Arm

and tire moulds used in the rubber industry. Since each of these moulds weighs several hundred pounds, it is difficult to handle them without machinery but by means of this truck they are readily moved from place to place as desired.

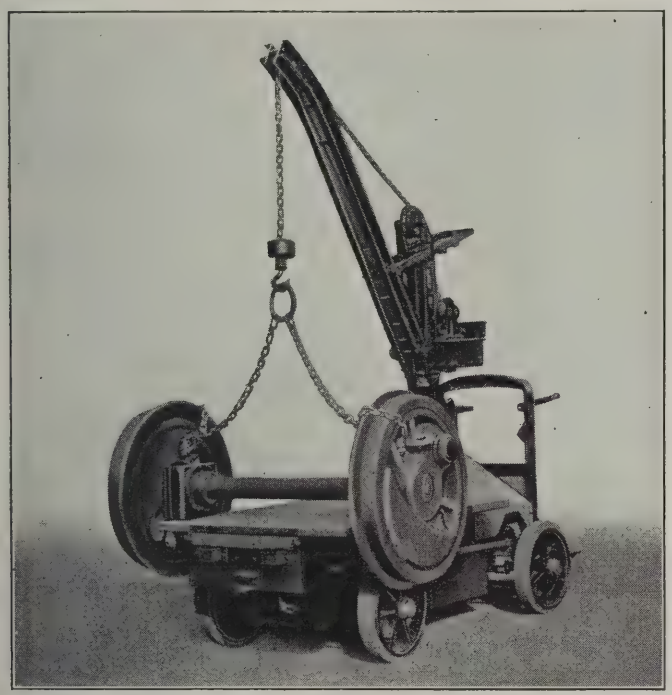
The truck is sometimes used for carrying coils of wire, as illustrated, in which case the truck is advanced with the carrying ram at the proper level to insert in the inclined pile of coils. The carrying ram is then elevated and lifts the coils from the floor when they can be moved to their desired destination and placed in racks or hung up on pegs. Although developed for the rubber industry alone, this truck has shown that it has quite a wide application, being adaptable to handling material in railroad shops and storerooms.

The mechanism of the truck consists of a carriage

mounted on rollers running vertically between channel guides and lifted by an electrically driven cable hoist. The hoist motor is controlled by a small reversing switch, mounted on the dash and its operation in both directions is limited by suitable switches. The truck has a capacity to raise and support a weight of 2,500 lb. when spaced evenly on the ram.

Electric Truck Equipped with Crane

Storage battery trucks have demonstrated their ability as labor saving devices in railroad shops and storerooms and many of these trucks are now equipped with devices to facilitate loading and unloading. To eliminate manual labor as much as possible the Yale & Towne Mfg. Co., Stamford, Conn., has developed the crane-equipped truck,



Crane-Equipped Truck Carrying Small Driving Wheels

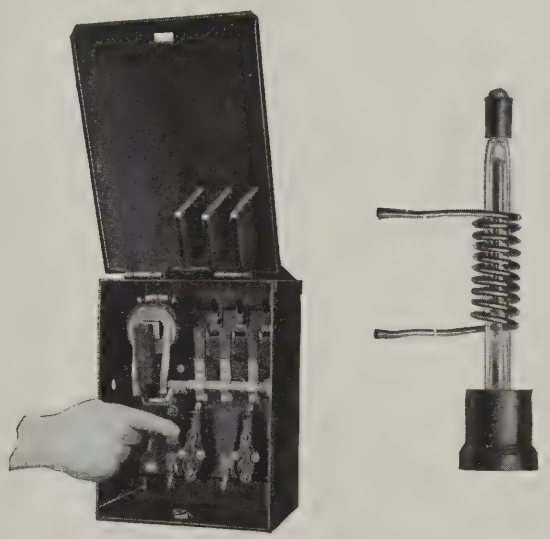
illustrated, with a total load carrying capacity of 4,000 lb. It can be run at speeds up to 6 miles an hour loaded, negotiating grades up to 12 per cent, and run over any road that presents a reasonably smooth surface. It does not need to be jockeyed into position before lifting the load, which may be picked up by the crane from either side of the truck or from the end, since both the boom and load chain may be raised simultaneously, thus lengthening or shortening the reach of the boom as required. The crane has a total capacity of 1,600 lb. at the maximum out-reach position of 69½ in. from the center line of the mast. This load capacity increases as the out-reach decreases until at a distance of 24 in. the crane will pick up 1,900 lb.

The truck illustrated has been subjected to severe tests, it is said, with satisfactory results, and experiments are now being carried on at the plant with the idea of equipping the truck with an electro-magnet and dump body. The dump body will be especially valuable for use in picking up and handling scrap metal quickly. The assembled wheels and axles, shown in the illustration, weigh approximately 1,800 lb., a load which would require considerable effort on the part of two or possibly four men to roll these wheels onto the truck without the crane.

Automatic Starter for Squirrel Cage Motors

A new automatic starter for small squirrel cage motors which allows a large starting current for several seconds but at the same time gives positive protection against burnout troubles has been developed by the Cutler-Hammer Manufacturing Company. Two mercury overload relays mounted below the contact fingers, shown in the illustration, take the place of fuses and allow momentary overloads and overloads as high as 25 per cent for a limited period without injury to the motor.

The overload relay consists of a glass tube carrying a mercury column which forms a part of pilot circuit of the magnetic switch coil. A portion of this column is surrounded by a heating coil or thermal element. This element is in series with the motor circuit and is heated in the same proportion as the motor windings. Excessive current passing for too long a period heats the coil, causes the mercury to boil and the vapor to pass up into a chamber at the top of the tube. This action breaks the liquid mercury column and opens the circuit of the magnet coil. As this coil is de-energized, the contact fingers drop away and disconnect the motor from the line. After



Automatic Starter and Mercury Overload Relay

such an interruption, the mercury cools down, becomes liquid again, drops back into the tube so that the pilot circuit to the magnet coil is complete when the control button is depressed. Very little time is required for the relays to reset themselves. The motor will not start, however, until the control button is depressed after the relays have reset.

As the functioning of these overload relays depends upon the temperature at which mercury will boil, it is evident that the current required to operate the relay increases with the decrease in the temperature of the surrounding air. In other words, if the motor and the starter are installed in a cool location, the relay permits a greater starting current or a higher overload than if the temperature of the surrounding air were higher. Likewise, if the motor and starter are located in an unduly hot place, the mercury relays will act in the place of a thermo-couple.

General News Section

The Union Pacific, on July 17, re-employed 1,500 men on its Mountain division who had been laid off with the slump in business.

The Western Electric Company has opened a new warehouse at 395 Hudson street, New York City. The building occupies the entire square block bounded by Hudson, West Houston, Greenwich and Clarkson streets, an area of 338 ft. by 200 ft., with a total floor space of 706,000 sq. ft. Several departments of the Western Electric have already moved into the new quarters, but the New York shops and the supply divisions of the Eastern district territory, which includes New York, New Jersey, Pennsylvania and the New England states, and the International Western Electric Company will not remove to the same building at the present time.

The Delaware, Lackawanna & Western Railroad rejected all bids for supplying electrical equipment for the proposed electrification of some of its mileage in the Scranton, Pa., district. July 29 was the last day upon which bids could be submitted. When the bids were opened by Gibbs & Hill, consulting engineers for the Lackawanna, it was found that they were all unsatisfactory and new bids were advertised for, which were closed at 12 o'clock noon, August 10. The only companies which submitted bids for furnishing the heavy electrical equipment, consisting of seven freight locomotives, were the General Electric Company and the Westinghouse Electric & Manufacturing Company.

"Practical Application of the Electric Arc Welding Process" is the title of a paper to be presented by E. Wanamaker, electrical engineer, Chicago, Rock Island & Pacific, before the Metropolitan Section of the American Welding Society on September 20, at the Engineering Societies' building, 29 West Thirty-ninth street, New York. The paper will deal with the three prime requisites of welding: namely, skill necessary in applying weld or designing parts to be welded, requirements of equipment, and quality of material to be used in welding. Mr. Wanamaker is one of the few who can present this subject in a manner which is interesting, and so that it will be of benefit to both the engineer and the practical welder.

The Waterbury Battery Company, Waterbury, Conn., has completed a reorganization of its officers and directors, which has been occasioned by the deaths of Charles B. Schoenmehl and E. E. Hudson. The officers of the company are now Martin L. Martus, of Waterbury, Conn., president; G. A. Nelson, vice-president and general sales manager at New York; Francis T. Reeves, treasurer, and Harold B. Schoenmehl, secretary, both at Waterbury. The directors are: Francis T. Reeves, Martin L. Martus and Darragh De Lancey.

Martin L. Martus, who has been elected president, has been associated with the company since April, 1911; for the past nine years as secretary and factory manager. He was born in New Haven, Conn., and became associated with the Scovill Manufacturing Company in 1901. In 1906 he was chief engineer for one of the subsidiary plants of The American Brass Company, and in 1911 became associated with The Waterbury Battery Company as factory manager, which position he has held until the present time.

Judge Francis T. Reeves, treasurer, was born in Thomaston, Conn., and has been a director of The Waterbury Battery Company since October, 1916, and its general counsel since 1914. He is director and trust officer of The Manufacturers National Bank, of Waterbury, Conn., and is a practising attorney in Waterbury.

Harold B. Schoenmehl, the newly elected secretary, is the eldest son of the late Charles B. Schoenmehl. He has been associated with The Waterbury Battery Company for the last six years, engaged in laboratorial and experimental work.

Darragh De Lancey, the newly elected director, was formerly president of The Waterbury Chamber of Commerce and during the late war served with the War Department and the United States Shipping Board.

Steel Passenger Cars for the Northern Pacific

Sixty-two passenger cars are being rebuilt by the Pullman Company for the Northern Pacific which will be used on trains Nos. 1 and 2 running between St. Paul and Seattle. A part of the order has been delivered to the railroad company and when completed will consist of 22 coaches, 12 diners, 11 dynamo baggage cars, 12 baggage cars and five mail and express cars. Three business cars are also being rebuilt in similar manner. All of the equipment used on these trains will then be steel. The cars are similar to the latest design of Pullman cars and are built of wood with steel underframes and ends and ⅛ in. steel sheathing. The trucks were reinforced to carry the added weight. The advantages ascribed to this type of construction over the all-steel construction are that they are less noisy, are warmer in winter and cooler in summer and more resilient in case of impact.

The head end system of lighting with power supplied by a steam turbine driven generator, located in the baggage car, is used on these trains. New switch panels were added to the cars, but the lighting fixtures were not changed. Storage batteries will be used on each car, excepting coaches and straight baggage cars.

Hydro-Electric Power in Argentina

Recently published details on the Argentine government's scheme for utilizing the Iguazu Falls and the Salto Grande for the generation of hydro-electricity represent the available head of water as varying from 154 ft. to

280 ft. and the flow as ranging from 12,000 cu. ft. to 250,000 cu. ft. a second. The average flow is put at 50,000 cu. ft., and it is estimated that the development would mean a fairly constant output of 370,000 hp., most of which would be taken by Buenos Aires.

Wireless in Latin America

Announcement has been made that one of the most powerful wireless stations in the world is soon to be erected at Buenos Aires to operate between Argentina and Europe. There will be six 689-ft. towers, and the station is to be erected under contract with the Telefunken Radiographic Company of Germany. In Mexico the government has approved of the erection of thirty additional wireless stations and has besides overhauled and put in good condition the twenty-seven stations now in operation in that country.

Electrification in Jamaica

A bill authorizing the Jamaican Government to take over the traction and light system of the city of Kingston, Jamaica, and to equip 127 miles of the National Railway for electrical operation is now being prepared by the Attorney-General for submission to the colonial office. The government proposes to borrow between $6,000,000 and $7,000,000 to carry out the project.

Contract for Chilean Electrification

A newspaper report dated July 20 stated that the directors of the Chilean State Railways had decided to accept the bid of the Westinghouse Electric & Manufacturing Company for the electrification of a section of the state railways.

A later report, issued by the *Wall Street Journal,* states that the contract which was awarded to the Westinghouse Electric & Manufacturing Company is contingent upon certain financial reservations which have not yet been accepted by that company. The report further states it is understood that the Chilean government has not yet found a means of financing the project, and the inference is that it is a condition of the contract that the company shall assist the government in arranging the financing, or shall accept bonds in payment and thereby be obliged to find a syndicate here or elsewhere to buy those bonds.

The contract involves the electrification of the line between Santiago and Valparaiso and the connection with the Trans-Andine line, from the junction with the Santiago-Valparaiso line, to Los Andes. The work will involve 200 route miles and the contract will amount to between $10,000,000 and $12,000,000.

Electric Locomotives for Switzerland

The Swiss Federal Railway Administration at a recent meeting approved the buying of 32 electric locomotives, according to Thornwell Haynes, United States consul at Berne. A credit of approximately $4,000,000, chargeable to the 1921-1923 construction account, was voted for this purpose.

French Railway Places Order with Westinghouse

An order for electrical equipment amounting to $1,200,000 has been received by the Westinghouse Electric International Company from the Midi Railway of France. The order includes transformers, synchronous condensers, lightning arresters and other substation equipment.

The Midi Railway operates an extensive system starting from Bordeaux, running through Toulouse to Cette, with many branches. The section on which the Westinghouse equipment will be used extends from Pau to Toulouse in the Pyrenees Mountains near the Spanish border. The line passes through Tarbes and St. Gaudens, and has a total length of about 100 miles.

Personals

A. F. Zacher has resigned as district manager of the Buffalo office of the Economy Fuse & Manufacturing Co., Chicago.

W. J. Crawford is now with the Electric Storage Battery Company, New York City. Until recently he was sales engineer for the Cutler-Hammer Manufacturing Company, New York.

Paul C. Bandy, formerly handling the sales work in the industrial heating department of the Cutler-Hammer Manufacturing Company in the western district, is now manager of the industrial heating department of the Russell Electric Company of Chicago, who have recently entered the industrial heating field in an extensive way. The industrial heating line of the Russell Electric Company will carry the "Hold-Heet" trade name and the line includes standard and special space heaters, steel clad conduction heaters for practically every heating purpose, industrial immersion heaters, glue pots, solder pots and all types of special heating units.

Charles S. Pflasterer has resigned as assistant manager, railroad sales department of the National Carbon Company, Inc., Cleveland, Ohio, to become railroad sales manager of the Twin Dry Cell Battery Company, with office at Cleveland. Mr. Pflasterer was born in Allegheny, Pa., in 1875. After spending two years in the steel mills at Braddock, Pa., he became connected with the Union Switch & Signal Company, Swissvale, Pa., in 1891 as a laborer. In 1893 he entered the employ of the Johnson Railroad Signal Company, Chicago, and from 1894 to 1901 was connected successively with various signal companies, the Chicago & Eastern Illinois, the Cleveland, Cincinnati, Chicago & St. Louis, the Chicago Elevated Railways and the Chicago Great Western. In 1901, he was appointed interlocking foreman on the Union Pacific at Omaha, Neb. From 1901 to 1908, he was successively signal foreman, general signal foreman, superintendent

C. S. Pflasterer

of construction, general signal inspector and assistant signal engineer, and in 1909, was appointed assistant signal engineer of the Oregon Short Line, with headquarters at Ogden, Utah. In 1911, he became connected with the National Carbon Company, Inc., in charge of the caustic soda primary battery department. In October, 1919, he was appointed eastern manager of the railroad sales department at Cleveland and now resigns as assistant manager of the railroad sales department of the National Carbon Company, Inc., to become railroad sales manager of the Twin Dry Cell Battery Company, as above noted.

Aaron L. Nelson, of Deer Lodge, Montana, has sailed for South America. His address will be: General Electric Company, Caixa Postal 547, Sao Paulo, Brazil, S. A. Mr. Nelson has been with the General Electric Company since 1909, and represented it in the electrification of the Chicago, Milwaukee and St. Paul Railway.

G. A. Nelson, special representative of the Waterbury Battery Company, of Waterbury, Conn., has been elected vice-president and general sales manager, with headquarters at New York. Mr. Nelson was born in Chicago, and started his business career in that city with E. W. Gillett. In 1895 he was in Toronto, Ontario, in temporary charge of the Canadian business of E. W. Gillett, of Chicago. In 1897 he came to New York to open up and become manager of a branch factory of the Champion Chemical Works, Chicago, grinders and packers of caustic soda and similar chemicals. In 1901 he was elected secretary and treasurer of the Gordon Primary Battery Company, and continued his connection with that company until January 1, 1916, at which time he accepted the agencies for several lines of railway tools and supplies. In March, 1917, he was appointed special representative of the Waterbury Battery Company, and he now becomes vice-president and general sales manager of the same company, as noted above. Mr. Nelson has been an active member at the various railroad conventions. Since 1914 he has been secretary-treasurer of the Railway Telegraph & Telephone Appliance Association.

G. A. Nelson

Obituary

Albert Taylor, manager of the North Atlantic district, of the Electric Storage Battery Company, Philadelphia, Pa., died suddenly on July 6. He was taken ill in his office in New York City and died a few hours later in a hospital. Mr. Taylor was born in Liverpool, England, on February 6, 1864, and in 1884, he was graduated from Princeton University. He served an apprenticeship with the Edison General Electric Company and in 1885, joined the United States Electric Company. This company was absorbed by the Westinghouse Company in 1889, and in the Spring of 1890, Mr. Taylor became associated with the Stanley Electric Manufacturing Company, Pittsfield, Mass., remaining in its employ for eight years. In 1898, he entered the service of the Electric Storage Battery Company, as a salesman in its New York office. In January, 1900, he was made assistant manager; in March of the same year he was appointed manager of the New York office, and since February, 1920, he was manager of the North Atlantic district.

Francis Bacon Crocker, noted electrical engineer, died at his home in New York City on Saturday, July 9. Professor Crocker was born in New York City in 1860. He was graduated from the School of Mines at Columbia University in 1882. Later he founded the School of Electrical Engineering at Columbia University and was the head of that school for nearly twenty years. His most conspicuous contribution to the electrical industry was the commercial motor, the first of which was put into use in 1886. In company with Charles G. Curtiss and Dr. Schuyler S. Wheeler he produced these machines, which were the forerunners of the present electric motor. In addition to his scientific and scholastic work he was active in the commercial applications of electrical equipment, being one of the founders of the C. and C. Company and the Crocker-Wheeler Company, of which he was director at the time of his death. During the war Professor Crocker was an adviser to the members of the Naval Consulting Board and, in company with Peter Cooper Hewitt, he developed the first helicopter in this country which was capable of flight.

Trade Publications

The Holtzer-Cabot Electric Company has issued a 16-page booklet describing and illustrating its fire alarm, watchmen's clock and audible signal systems for use in railway service and elsewhere.

The Sangamo Electric Company, Springfield, Ill., has issued a small two-fold pamphlet which lists and illustrates the various models and types of meters manufactured by that company, and states where they are made and where they are sold.

The Holtzer-Cabot Electric Company, Boston, Mass., has recently issued a small 16-page illustrated booklet listing the various types of electrical signaling devices which it manufactures. The line of equipment is very complete, comprising hospital signaling systems, fire alarm systems, calling systems, bank signal systems, watchman's clock systems, etc. Both visible and audible apparatus is included. The company also manufactures radio receiving head sets and telephone extension brackets or arms for desk mounting.

Auxiliary Apparatus for Electric Arc Furnaces is described in an 8-page bulletin No. 4871OB issued by the General Electric Company, Schenectady, N. Y. The apparatus described in the bulletin consists of transformers, switchboards, motors, reactors, electrode regulators, small motor-generator sets, cables and other accessories. The characteristics of electrode motors and tilting motors are treated separately, and the bulletin covers protective equipment for furnaces where this is found necessary. A wattmeter record shows the advantage of automatic electrode control over hand control.

Railway Electrical Engineer

Volume 12 SEPTEMBER, 1921 No. 9

The Convention in Doubt

At the time of going to press it is doubtful if the regular annual convention of the Association of Railway Electrical Engineers will be held. In the spring, when it was decided to omit the semi-annual meeting of the association, notices were sent to members advising them of the decision, and at the same time stating the place and date of the fall meeting. Recently, however, the Association of Railway Executives suggested that the various sections of the American Railway Association postpone indefinitely all conventions or curtail them as much as possible. While the Association of Railway Electrical Engineers is not officially connected with the American Railway Association, there is reason to believe that the influence of the Association of Railway Executives will be sufficient to effect a cancellation of the annual meeting of electrical men. The actual decision will be made by the association's board of directors which meets on September 10.

Convenient Headlight Maintenance

From custom, rather than from reason, the location of headlight generators has been almost invariably at some point on top of the locomotive boiler. The obvious thing is that which is frequently overlooked, and it is certainly obvious enough that a piece of equipment requiring more or less frequent inspection should not be located in the most inaccessible place possible. Why must the headlight generator always be placed on top of the locomotive where it is not only difficult to inspect, but where, due to the heat of the boiler, the inspection is accomplished with no small amount of physical discomfort. Physical discomfort is rarely sought after and there is nothing more logical than that headlight maintenance should be slighted in direct proportion to the hardships involved in its accomplishment.

The idea may seem quite reactionary and it certainly is original to have the turbo-generator located on a special bracket *under* the smokebox, but the suggestion has been offered by a man who has made a study of the situation and it must be admitted that it is not without merit. With the equipment in such a position it is readily accessible wiih a minimum of inconvenience and discomfort and is almost certain to enjoy better maintenance than in most of the locations which it commonly occupies at present. It is suggested that the turbine discharge into the smokebox instead of into the air. Of course, a longer steam pipe would be required than is needed by many of the equipments now in use, but this does not appear to be a serious obstacle.

It cannot be denied that locating the turbo-generator under the smokebox is a unique suggestion and until it has been actually tried, it would be difficult to determine what objections, if any, there could be to this new location. It will be interesting to study the first installation of this kind. What do you think about it?

Maintenance of Car Lighting Batteries

Washing, cleaning and repairing lead storage batteries for car lighting service does not involve a great number of operations but there is probably no other work done by the electrical men on the steam railroads which is performed by such a variety of methods. The batteries used by the different roads and the conditions under which they operate are at least similar, but it appears that each road, or in some cases each shop where repair work is done, has developed its own particular methods of taking care of lead car lighting batteries. In general, the methods do not differ greatly, but the detail schemes and stunts used in the different shops are almost as many as there are shops.

There is no railroad which has as many batteries to care for as has the Pullman Company and probably there is no railroad that has as highly developed a system for maintaining batteries. This method is described elsewhere in this issue and it is well worth the attention of all who are interested in battery maintenance. Probably there are few roads that need such elaborate means for the care of their batteries, but it has taken much time, study and work to develop the system used by the Pullman Company and undoubtedly a number of methods and devices described can be used advantageously by some of the railroads.

Electrification, Foreign and Domestic

There is much activity in European railway electrification. European railroads are harder pressed than those in the United States by financial difficulties, labor troubles, etc., but in spite of this they are going ahead with extensive programs of electrification involving the expenditure of many millions of dollars. The principal reason is that fuel is scarce, high priced and difficult to obtain. Dr. Frank B. Jewett, chief engineer of the Western Electric Company, has just returned from a three-months' trip through

Europe and has made a report of conditions, an abstract of which follows:

"Plans are now laid in virtually all European countries to harness their water power so as to produce electricity. In Switzerland, Italy, Norway, Sweden, Denmark, and even England, detailed plans for development of natural water power for the electrification of railroads are under discussion.

"In those countries where there is a scarcity of coal, hydro-electrical development is of vital importance. In England, while tremendous electrical development is being considered, the absence of any considerable water powers and the relative abundance of coal gives this problem a somewhat different trend from that observed in continental Europe. While the continental projects contemplate the development and linking together of hydro-electric plants, it is probable that in England the development will be along the lines of establishing enormous generating stations at or near the mine mouths and linking these stations together and to main-line distribution systems for supplying energy wherever needed in England, Scotland and Wales. As on the Continent, the scheme under contemplation in England involves extensive electrification of trunk-line railroads.

"In the Scandinavian countries the fuel situation makes a substitute for power derived from coal a matter of economic life and death. There is talk of combining the natural resources of Norway, Sweden and Denmark. The electricity could be distributed where it was needed. Norway has enormous natural water resources, Sweden not so many, and Denmark very few. The energy would have to be transmitted by submarine cable in many cases, and this fact presents some interesting engineering difficulties. However, Copenhagen utilities are now being run to a considerable extent by Swedish power brought over by submarine cable.

"The immediate difficulty in carrying out these extensive developments is the financial situation. That is all that is holding them back. They hesitate to borrow 50 per cent money which they will later have to pay back in 100 per cent money. It is probable, therefore, that little will be done until the currency has recovered somewhat from the present depreciation."

America is faced by no such coal shortage, but in all probability the price of coal will eventually increase enough to make the electrification of certain sections of road more and more desirable. Fuel cost is by no means the principal factor governing the adoption of electric traction in this country—increased track capacity, for example, is a better argument for favoring electrification—but fuel is a factor of increasing importance and in cases where the decision has been in the balance for some time, it may be sufficient to cause a road to use electric motive power. As is the case in Sweden, the American railroads hesitate to borrow money which will later be worth more than it is now, but that condition is passing and we seem to be on the threshold of an era in which electrification will be extensively adopted.

Enginehouse Lighting

Enginehouse lighting, like enginehouse wiring, is a problem which no one claims to have solved to his entire satisfaction. The electrical engineer of a western road recently said, "If there is someone who knows how to light enginehouses, I'd like to have him tell me how it is done." The difficulties are caused principally by the facts that everything in the house is black and does not reflect light; dirt accumulates rapidly which covers the lamps and reflectors; and at times there is an overhanging vapor, the lower limit of which is known as the steam line, that obscures the light if the unit is placed too high; moreover, the spaces to be lighted are long and narrow. In addition to these difficulties the light must be so located and directed that it will be of benefit to the men working on the locomotives and will not project a glare into the eyes of the engineman bringing the locomotive into the house.

In spite of all these difficulties, enginehouses are lighted, the old oil torch is practically obsolete and the problem of the electrical engineer is to select the system most suitable to the requirements and if possible to discover some way of improving it. There are three general methods of lighting in use; (1) overhead lights with reflectors mounted between stalls and over the runways as high as will be permitted by the steam line; (2) a larger number of smaller lights on cords between stalls hung nearer to the floor than those in the first case; (3) headlights or floodlights mounted on the wall of the outer circle or both inner and outer circles.

Overhead lighting with high-mounted units is, of course, the best where it is practicable, but the reflectors get dirty quickly and as it is not easy to clean them they frequently are left a long time without cleaning. Furthermore in localities where the winters are cold, the steam line comes down so low that the lights do not function. Perhaps some kind of a disconnecting hanger which would facilitate the cleaning of the units would make this the best of all the methods.

When the reflectors are omitted and the units placed lower, the light is down where it is available, but it is of a poorer quality and the theft and breakage of lamps is increased. Due probably to the shortcomings of other methods this method is in very general use.

The older types of headlights caused objectionable glare and gave a light that was not easy to work by. The use of reflectors giving a wider dispersion of light, mounted in pairs with crossed beams, has greatly improved this form of lighting. It is still a light which is projected onto the work at a low angle but the lighting is effective and as the lighting units are low and have a glass cover, they are easy to clean.

Choose the system best adapted to your needs depending upon the amount of steam and smoke in your enginehouse, the amount of space between stalls, the location of the supporting columns and the facilities you have for renewing lamps and cleaning reflectors and tell the *Railway Electrical Engineer* about any improvement or new system you have developed so that the information can be passed on to others.

New Books

E. M. F. Electrical Year Book. First Edition, 9 in. x 12 in.. Bound in cloth. 843 pages illustrated. Published by Electrical Trade Publishing Company, 53 West Jackson Boulevard, Chicago, Illinois.

The book is called a combined dictionary, encyclopedia and trade dictionary of the electrical industry and comprises three leading features; compilations of facts and figures about each branch of the industry, definitions of electrical and allied terms and a classification of products made and used by the industry with listings of their producers. For example, the book lists the aims and activities of the Association of Railway Electrical Engineers, and it describes 21 different types of sockets for electric lamps, listing the manufacturers of each type. It contains a short treatise on electric locomotives and does not omit small things, such as locknuts and bushings for conduit. Household, as well as shop, appliances are included and it is the object of the publishers to make it a useful annual reference book. The book contains a liberal education for any electrical man and should be of real value to anyone whose duties involve the use or selection of a wide variety of electrical apparatus. About 30 writers, including college professors, electrical engineers and other specialists have contributed material and the book was compiled and edited under the direction of Frank H. Bernhard.

New Coaling Stations on the Santa Fe

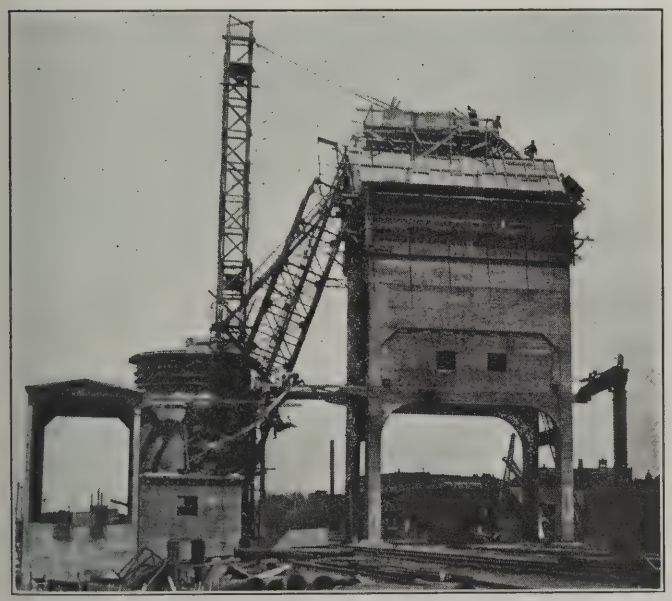
Automatic Electrical Control Permits Continuous Operation of Bucket, with Capacity of Seventy-Five Tons an Hour

THE Atchison, Topeka & Santa Fe has recently placed in service at Dodge City, Kan., a 400-ton reinforced concrete automatic electric coaling and sanding plant built by the Roberts and Schaefer Company, of Chicago. This plant was designed and erected by the above contractors under the jurisdiction of F. M. Bisbee, chief engineer of the Santa Fe lines, Amarillo, Texas. A plant similar to that shown in the above illustration has also been constructed for the same road at Guthrie, Okla.

The station has an overhead storage capacity of 400 tons of bituminous coal, serving two outbound tracks running under the pocket and two inbound tracks, one on each side of the pocket. The coal supply track is located at the north side, 37 ft. from the first inbound track.

Construction

The main pockets, the house over the pockets, and the hoist house were constructed of reinforced concrete of the proportion of 1:2:4 while the lower portion of the tower and canopy over the receiving track are built of structural steel. The car shed is enclosed with "Armco" corrugated galvanized iron. The entire station was completed in five months.



Coaling Plant at Guthrie, Okla., Under Construction

The Handling of the Coal

The coal is dumped from the car into a concrete receiving hopper under the supply track, from this hopper the coal is automatically measured through a 2½-ton measuring feeder that loads the coal into a 2½-ton bucket which in turn carries the coal to the overhead pocket.

Two 12-ton steel weigh-hoppers, each hanging on an 18-ton Strait scale, are suspended from the floor slab of the pocket. Each hopper is provided with two "Rand's Safety First" undercut coaling gates and apron fixtures. The filling of the weighing hoppers and the operation of the aprons and gates to coal engines and record the draft taken is handled by an operator located in the enclosed concrete house over the tracks at the proper weigh-hopper level.

Dodge City Coaling Plant

The Handling of the Sand

The sand is dumped in the same manner as the coal, elevated and discharged by the same bucket, into the dump chute and by-passed through a steel chute to a 50-ton reinforced concrete wet-sand bin. Through two gates at the bottom of this bin the sand gravitates into two "Beamer Patent" steam sand dryers, which are made of 1¼-in. pipe coils bent in rectangular form tapering toward the bottom with a side slope and spacing between the coils so as to allow the dry sand to fall through into a steel gathering hopper, but holding the wet sand. Below the hopper is placed a Tyrone automatic sand drum, from which the sand is elevated by means of compressed air to an overhead concrete bin holding 10 tons. From this bin the sand flows through a moisture-proof undercut sand valve and telescoping spout to each of the four tracks.

Machinery

The machinery consits of a 2½-ton ball bearing elevating bucket, a balancing counter-weight cable electrically operated drum hoist and the automatic controller equipment. As shown in the illustration this big bucket operates in a steel incline tower between the track hopper and the pocket. A seven-eighths-inch cable runs from the bucket to overhead sheaves then down to the hoist located in the small building at the lower left of the picture.

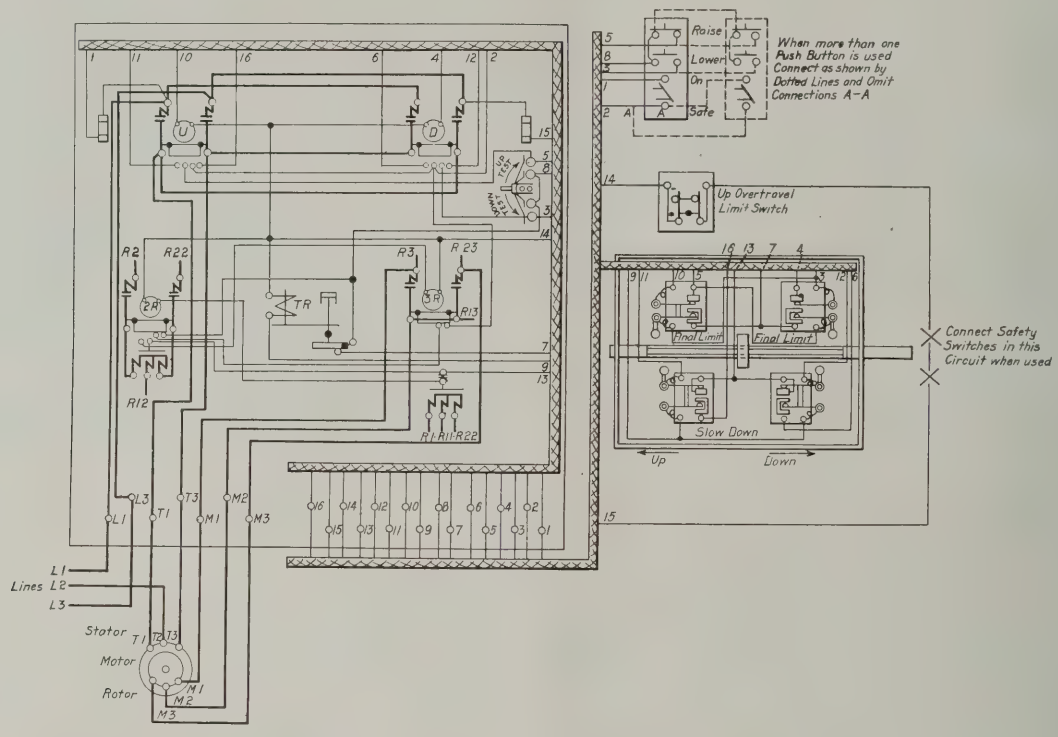
The hoisting drum is directly connected through spur gears and a herring-bone gear to a 22 hp., 220-volt, 60-cycle a.c. motor provided with a solenoid brake. This motor is so controlled as to permit the continuous ascent and descent of the elevating bucket without the services

of an attendant. Under normal conditions the bucket will carry up a load, dump and return and be filled again in two minutes.

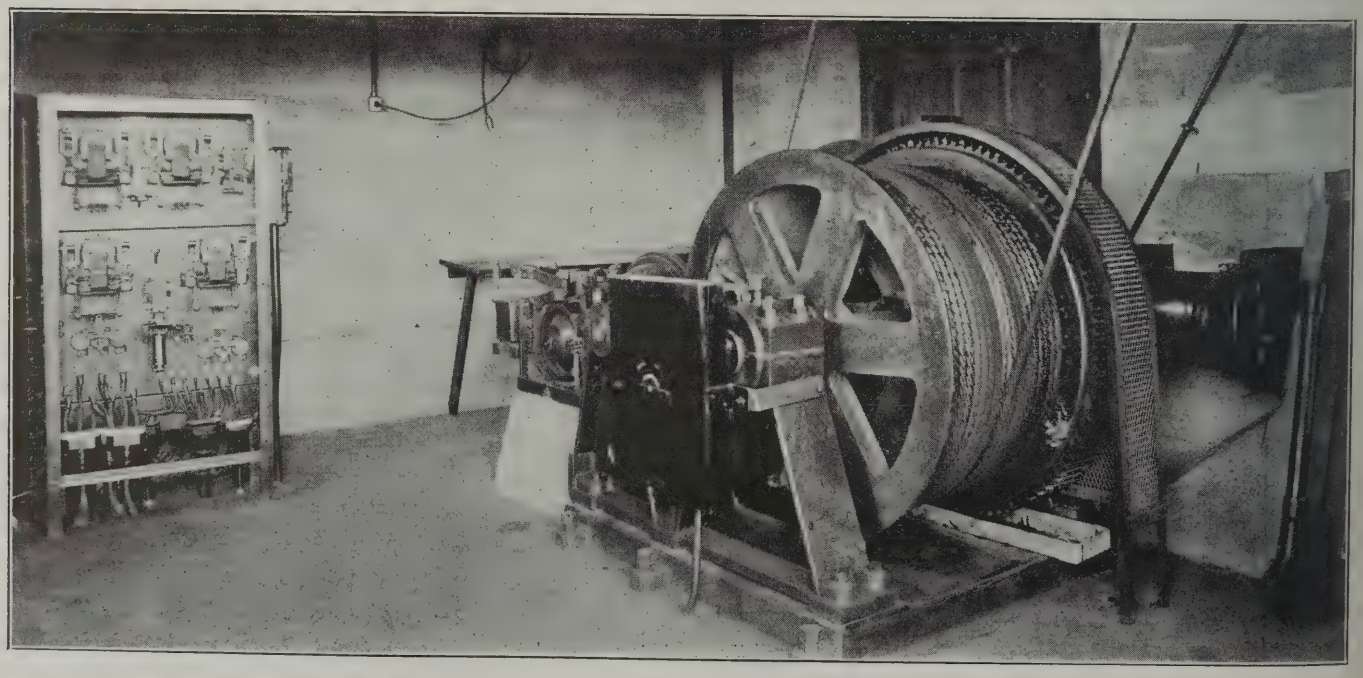
Description of the Skip Hoist Controller

The electrical control equipment manufactured by the Cutler-Hammer Mfg. Co., consists of a panel containing the magnetic contactors mounted in a sheet steel enclosing case which also contains the accelerating resistance, a machine limit switch which is geared to the winding drum, a push-button station and a geared type over-travel limit switch.

The panel contains two double-pole magnetic contactors which handle the primary of the motor. One of these contactors is closed for each direction of the motor. There are also two double-pole magnetic contactors to handle the secondary circuit. They are controlled by series relays which allow them to close when the current peaks have dropped to the proper value, thus shorting out the rotor resistance and bringing the motor up to speed. During the slow down period these contactors again open and insert the rotor resistance and thus slow down the motor. The panel also contains a timing relay which automatically starts the motor in the opposite direction after a definite time interval. There is an auxiliary relay which serves to prevent the motor from reversing



Connections for Skip Hoist Controller

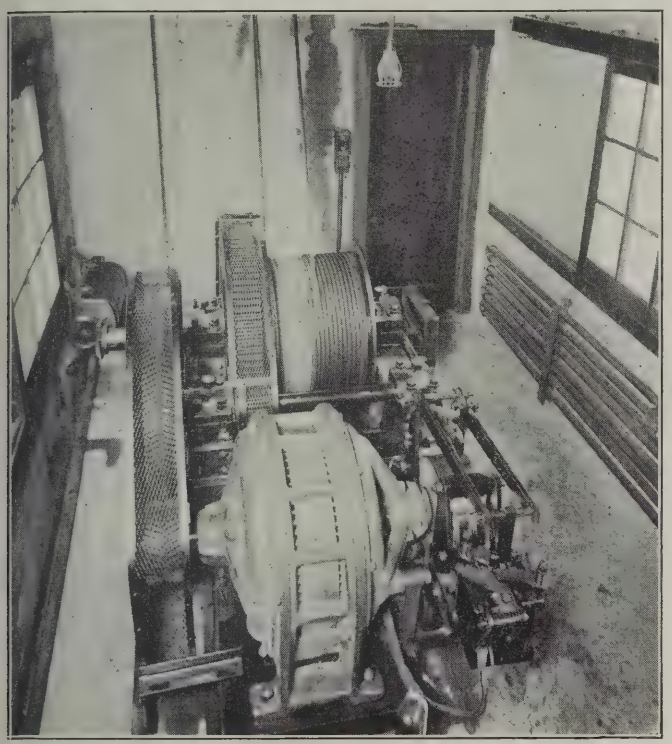


Electrical Automatic Control Panel. Winding Drum Shown at the Right

immediately in case the timing relay should fail to operate.

The machine limit switch, located on the wall, contains four elements, a final and a slow down limit in each direction. These elements are operated by a traveling nut on a screw shaft, the shaft being geared to the winding drum causing the nut to travel along its length and trip the slow down and final limits when the skip has reached the proper position.

The enclosed limit switch on the other end of the drum shaft, shown in the steel cabinet, is the final safety switch, should the cable start to overwind, this switch immediately cuts out the current bringing the machine to



Another View Showing Relative Positions of Motor and Winding Drum

rest. The over-travel switch is mounted just beyond the final limit in the up direction and serves to stop the equipment should it pass the final limit.

The push-button station contains two buttons marked "raise" and "lower," and a snap switch marked "on" and "safe,"—the skip starting up in the proper direction when either the "raise" or "lower" button is operated. The equipment is stopped by operating the snap switch in the "safe" position. The motors cannot again be started until the snap switch is first moved to the "on" position. Once the equipment has been started by means of either the "raise" or "lower" button, it will continue to alternately hoist and lower until stopped by the "safe" button.

Preliminary compilations of railway returns for the month of July, the first month since the wage reduction took effect, show an improvement over previous months. The net operating income for 172 roads was $57,254,000. In June all the Class I roads earned about $51,000,000. To earn at the rate of 6 per cent, all the Class I roads should earn about $90,000,000 for July. The total operating revenues of 172 roads show a decrease of 13.1 per cent, while their operating expenses show a decrease of 29 per cent.

Austria Plans Extensive Electrification

DURING 1920 Austria imported 4,800,000 tons of coal, and if minimum requirements are to be met in 1921 about 7,000,000 tons will have to be imported, which will cost about 24,000,000,000 Austrian kronen ($47,500,000 at the present rate of exchange). This coal comes principally from Czecho-Slovakia and Upper Silesia. Austria produces about 20 per cent of its requirements, but the coal is of such a poor quality that but little of it can be used on locomotives. On account of the high price of export coal there is every incentive for railway electrification, particularly so because of the large amount of water power available. It is estimated that there is a potential of 2,500,000 hp. to be developed by hydro-electric plants of which only 205,000 hp. is now being used. By proper development of this source of energy some 6,000,000 or 7,000,000 tons of coal could be saved.

The present economic and financial conditions in Austria permit of only gradual development. On account of the precarious financial situation the government has reduced the credit already granted for the electrification from 1,200,000,000 to 500,000,000 kronen. This and the prohibitive price of certain materials which, because of lack of coal must be purchased abroad, are hampering the progress of the work. Those lines are to be electrified first which have heavy grades and are located far from the coal supply. Facilities for the production of electric

Proposed Electrification in Austria. Dotted Lines Show Work to Be Undertaken First, Heavy Lines Indicate Projects for Future

current and traffic conditions are also taken into consideration.

On July 23, 1920, a bill passed the Austrian National Assembly which authorized the electrification within a period of seven years of 405 miles out of the 2,780 miles of railway lines administered by the Austrian government. The lines, which are shown on the accompanying map by a dotted line, are:

Innsbruck-German-Swiss border line	146 miles
Salzburg-Schwarzach-Worgl	119 miles
Schwarzach-Villach	73 miles
Steinach-Attnang	67 miles
Total	405 miles

The bill provides for the expenditure of a sum not to exceed 5,096,000,000 kronen (about $10,000,000) to be covered by an Austrian government bond issue repayable within 25 years from date of issue. An effort will be made to enlist foreign capital by mortgaging the railways themselves. So far all expenses have been covered by the

government without the issue of a loan and without foreign capital, although negotiations with foreign financial interests are in progress.

The bill further contemplates the electrification in a second period of seven years of the following lines, which are shown on the map by heavy solid lines:

Vienna-Salzburg	195 miles
Amstetten-Selzthal	114 miles
St. Michael-Villach	109 miles
St. Valentin-Kl. Reifling	42 miles
St. Veit-Klagenfurt	11 miles
Selzthal-Bischofshofen	61 miles
Linz-Selzthal	65 miles
Hiedau-Vordernberg	22 miles
Wels-Passau	50 miles
Worgl-Innsbruck	37 miles
Total	706 miles

If this is done, 1,111 miles or 40 per cent of the Austrian State Railway will have been electrified. The remaining lines by reason of the peculiar traffic will probably not be electrified at all.

The electrified lines will operate on single phase current at 16⅔ cycles per second. Power will be transmitted at 50,000-110,000 volts and transformed to 15,000 volts for the contact wire. It is to be noted that this is the same system in use in Switzerland.

The total available energy is estimated for the electric operation in question at 357,200,000 kw-hr. per year.

The power stations for the Innsbruck Swiss-German border line are the Rutz River station near Innsbruck and the Spuller Lake station near Danoefen. The sub-stations are to be located at Zirl, Rappen, Flirsch and Danoefen. The yearly capacity of the Rutz River power station amounts to 39,000,000 kw-hr.; that of the Spuller Lake power station to 25,000,000 kw-hr. Taking the density of the traffic in 1913 as a basis, the total energy needed from both stations amounts to only 43,000,000 kw-hr., whereby it can be seen that there will be a big reserve for increase of traffic. The Spuller Lake power station is a new plant while the Rutz River station has only to be enlarged.

The Spuller Lake power station, where work was started in September, 1919, will contain 6 units of 8,000 hp. each. At the beginning only 3 units will be used. The hydraulic work is very complicated.

The Rutz River station has at present a capacity of 8,000 hp. and will be enlarged to 16,000 hp. The reconstruction of the Rutz River station will be completed in the spring of 1922. The Spuller Lake power station and the substations between that place and Innsbruck are to be completed in the summer of 1923. Completion of overhead construction on the line Innsbruck-Telfs is expected for the fall of 1921, that of the line Telfs-Landeck for the winter 1922. Landeck-Bludenz the winter of 1923. By using the energy of Rutz River station electric operation on the Innsbruck-Landeck line is expected to become effective at the beginning of 1923; the electric operation of the Arlberg line between Landeck-Bludenz will probably not be possible before the beginning of 1924.

For the remaining lines to be electrified during the first period, two power stations have been planned, and work has recently been started. These stations are the Stubbach valley power station with 40,000 hp. for supplying the Worgl-Salzburg line, and the Mallnitz power station with 16,000 hp. for supplying the Schwarzach-Villach line. The substations will be located at Westendorf, Hochfilzen, Bruck, Fusch, Bischofshofen, Hallein, Hofgastein and Mallnitz. Work is expected to be completed at the latest by the end of 1926.

The electric energy for the operation of the Attnang-Steinach line will be taken from the existing Steg power station near Hallstatt owned by the firm Stern & Hafferl. The necessary work there is expected to be completed at the beginning of 1923, so that electric operations will then be possible.

Of rolling equipment only locomotives are to be secured. So far 27 locomotives—15 passenger and 12 freight—have been ordered from Austrian factories (Brown Boveri, A.E.G., Union and Siemens-Schuckert). This is about one-eighth of the locomotives needed for operation on all lines to be electrified. The passenger locomotives will be of the 2-6-6-2 type and the 2-6-2 type. The 2-6-6-2 engines will operate at a speed of 31 m.p.h. The capacity of these locomotives is about 25 per cent greater than that of the five driving axle steam locomotives now used. They have a rated horsepower of 1,850 at 30 m.p.h. and an overload capacity of 3,000 hp.

The freight locomotives will be of the 0-10-0 type with a rated capacity of 1,000 hp. at an average speed of 18.5 m.p.h. and an overload capacity of 2,000 hp. The cars to be used in the trains operated by electric locomotives will be the same as used for steam operation.

Photo by Ewing Galloway

Redwood Lumber on the Waterfront at Eureka, Cal.

Methods and Devices Used by the Pullman Company

Lead Storage Battery Maintenance and the Construction of a New Type of Cell

Part 1*

A HIGHLY developed system for maintaining lead storage batteries has been developed by the Pullman Company which has materially reduced the cost and time required for testing, washing and repairing and which makes it possible to keep a record showing the condition and location of each and every battery. This article describes the manner in which the work is done at

Fig. 1—View of the Charging and Testing Room Known as the Battery Department

Buffalo, N. Y., and the general methods are typical of those used in the other large Pullman repair shops.

Inspection

When the cars are shopped for general repairs the batteries are removed and taken to the electrical repair shop on an electric truck. A blank form is filled out each time a battery is removed or applied to a car and these forms are sent to the general office. This form records the name of the car, the number of the battery, number of cells in battery, cause of removal, type of battery, by whom maintained, and the date on which the work was done. The same form provides for a record of the removal or application of generators, regulators and meters. Before the batteries are taken into the building all the dirt on the covers and outside of the crates is removed with a steam jet. A piece of pipe flattened at one end provides the nozzle and this is connected to the steam line by a short piece of hose.

After the outside dirt is removed, the truck, with the batteries still on it, is run into the charging and testing room, Fig. 1, where the batteries are inspected, charged, discharged and charged. This room is designated as the battery department in Fig. 3 and is furnished with long low benches, the same height as the trucks. The benches are arranged with a number of cross aisles and one longitudinal aisle. There is a door for each cross aisle and the batteries are brought in through these doors by the electric truck.

After charging, the batteries are discharged at the normal rate and a performance record is kept which is made out on a prepared form called a preliminary battery discharge record. The specific gravity reading of each cell is taken at the end of each charge. A voltage reading is taken of each cell at the beginning of the discharge run and at the end of the first, second, third and fourth hours. After that, cadmium readings are taken to the positive and negative plate of each cell once an hour to the end of the eighth hour. The preliminary battery discharge form also provides space for making notations on the condition of different parts of the battery and recording the kind and number of repairs necessary.

Removing Covers and Elements

From the testing room the batteries are taken on a hand truck down the longitudinal aisle of the battery department (Fig. 3) to the battery cleaning room. A steam cover which just fits over the top of a battery crate is used to soften the sealing compound so that the covers can be pried off.

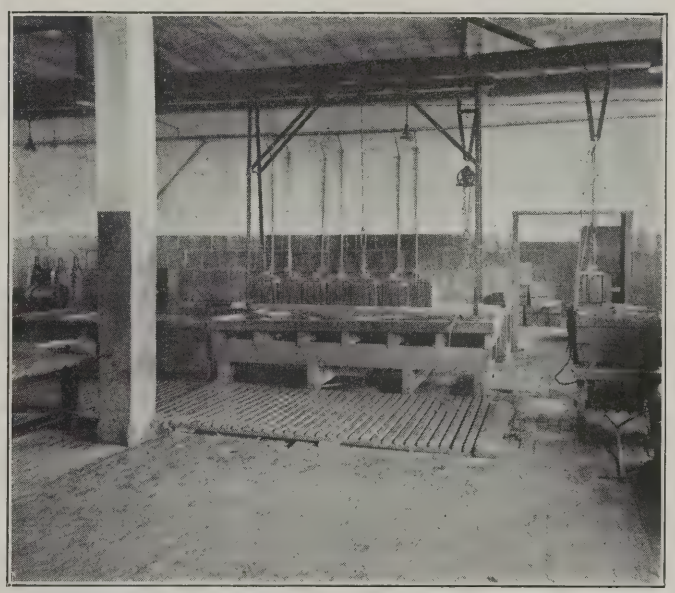


Fig. 2—View in the Battery Cleaning Room, Showing Dismantling Table in Center

Washing, Pressing and Assembling Elements

After the covers are removed the elements are lifted out of the tanks with self-locking blocks fitted with two hooks. One man places the hooks into the bolt holes in

*Part 2 will describe a number of devices developed and used by the Pullman Company in its electrical repair shops.

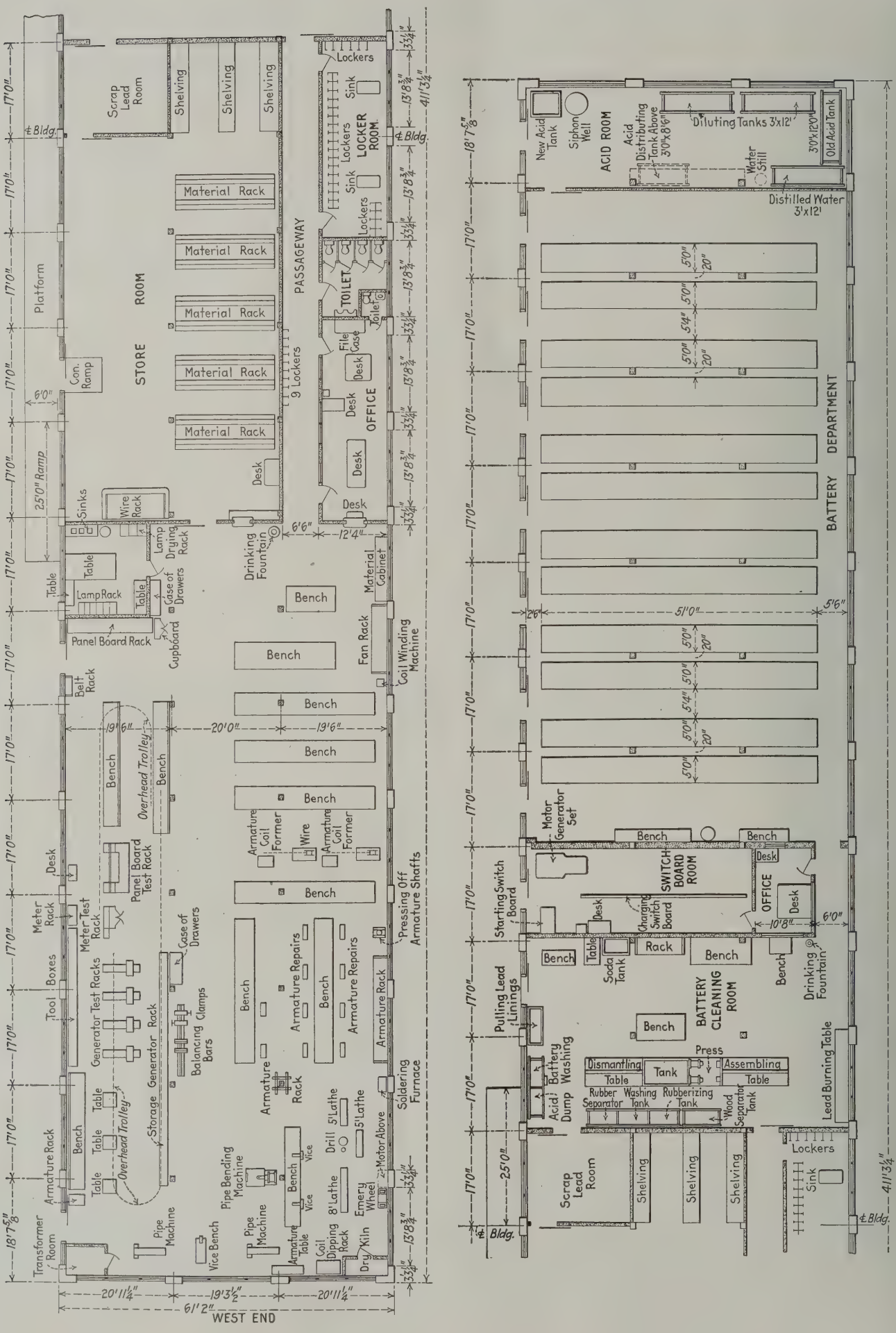


Fig. 3—Floor Plan of Entire Plant, Showing Arrangement and Location of Apparatus

the terminal lugs and holds the groups and separators while the other works the blocks. There are two sets of blocks, each of which travels on roller carriages supported on overhead I-beams over the entire length of the dismantling pressing and assembling table. There is also an elevated traveling table shown in Fig. 2, between the

Fig. 4—Assembling Table at Left Center. This Table Is Located in the Battery Cleaning Room and Is Separated from the Dismantling Table by a Tank and Press

two sets of blocks which can be moved in the same manner. These tables are covered with antimonial lead.

The dismantling table is also shown in Fig. 2 and its location with relation to other apparatus in the battery cleaning room is shown in Fig. 3.

If a set of elements is badly warped and grown so that

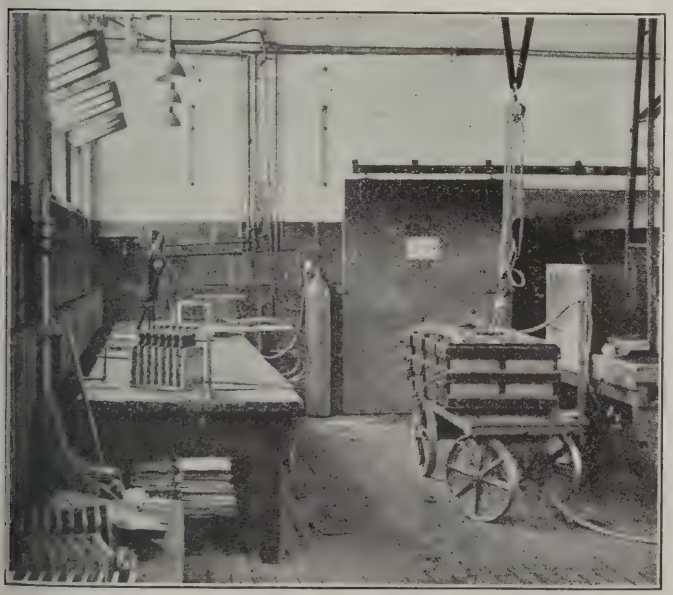
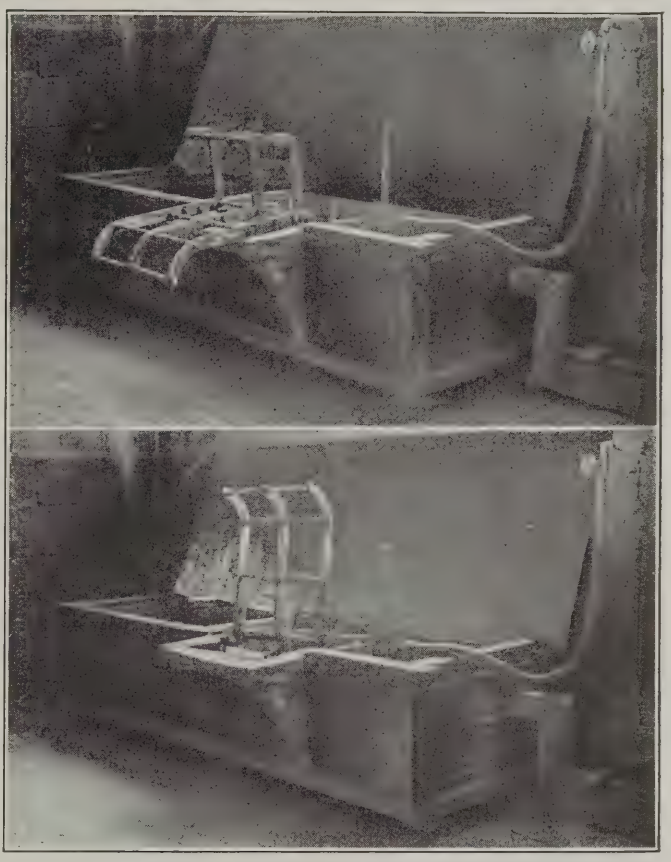


Fig. 5—Elements and Lining In Need of Repairs Are Taken to the Bench Shown at the Left

it is particularly stubborn about coming out of the tank, the battery crate is placed on the dismantling table and a half-ton chain block used to pull them out. A plank is used as a shore between the center partition of the battery box and one of the I-beams overhead to keep the crate down while the element is lifted out.

When the elements have all been removed and placed on the dismantling table, the separators are taken out and the elements washed with a hose. A large low velocity stream is used for this purpose. A piece of ¾ in. pipe serves as a nozzle and the water is turned on enough to project the stream about two or three feet.

After the elements are washed they are placed on the traveling table which is then moved along its track to a position between the two presses shown in Fig. 4. These presses are made with 10 in. air brake cylinders mounted in a horizontal position. Elements which are in need of straightening and trimming are taken off the traveling table here, straightened and trimmed and replaced on the



Figs. 6 and 7—Two Positions of the Rack for Holding Battery Tanks. This Rack Greatly Facilitates the Washing of the Tanks

table. Space blocks of a certain size and thickness are provided for each type of element. These blocks are of such a length that when placed with one end against the connecting strap, the other end will be flush with a plate of the proper length. If the plate has grown too long, the elements which need cutting, while still in the form, are removed to a hand saw table in the same room and the surplus material removed at one cut.

The tank shown at the right of the presses in Fig. 4 contains water and is used for cooling negative elements that show a tendency to heat up, or as a place to keep negative elements in case it is not convenient to reassemble the battery immediately after washing.

After the elements are trimmed and pressed into proper shape the traveling table is moved to the position over the assembling table shown in Fig. 4. The elements are

then laid on their sides on the assembling table and the separators which have been washed in a tank of water are slipped in between the plates. Broken separators are replaced with new ones.

The elements are then tipped up to a vertical position onto a two-inch plank which lies on the assembling table. The plank makes it possible to tip up the elements easily without displacing the separators.

After the elements are assembled the traveling, self-locking blocks are used to lift them into the tanks which have been washed in the meantime, placed in repainted crates, and brought on a truck to the extreme end of the assembling table. This operation is shown in Fig. 5. Thin copper sheets bent in the form of a V and placed over the lip of the tanks are used to guide the elements down into the tanks. The battery tanks are then filled with electrolyte from a hose fitted with a lead spigot. The electrolyte is carried by gravity from the acid room which will be described later.

Repairs to Elements and Lead Lining

All elements and linings that are in need of repairs are taken to the bench shown at the left in Fig. 5. When a strap is to be burned on to a group of plates, or new plates added to a group, the element is placed in a box containing a number of partitions and with two sides removed, also shown in the same illustration. The plates are thus held in position whether connected to the strap or not. Z-shaped pieces of boiler plate, bolted to the bench, are used for the shaping and repair of lead linings.

Washing Battery Tanks

The device used for washing battery tanks is shown in Figs. 6 and 7. After the elements and side sheets have

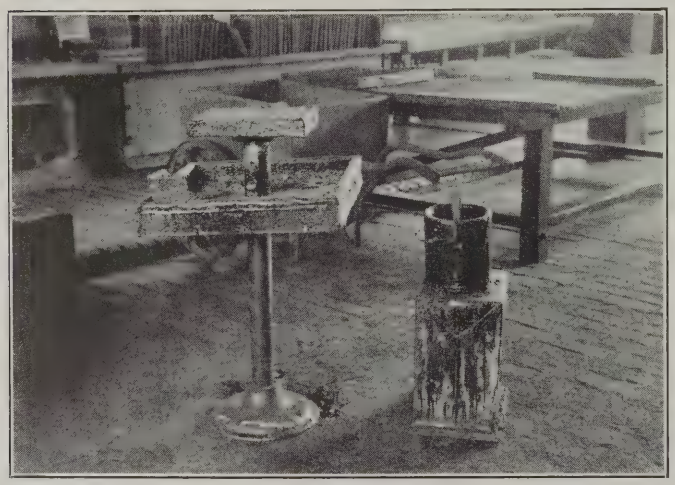


Fig. 8—Equipment Used in Painting the Lead Linings with Acid Proof Paint

been removed, the electrolyte is poured into the acid dump tank shown at the left and then the crate is placed on the cradle in the position shown in Fig. 6. The cradle is then raised to the position shown in Fig. 7, so that the battery crate is upside down over the two washing nozzles.

These nozzles can be moved back and forth about a horizontal axis by the lever and they are connected to both the water and steam mains. Water is turned on first and the nozzles moved back and forth until all the sediment is washed out, after which the water is turned off and steam blown into the tanks for a few seconds which completes the washing process and dries out the tanks.

The overflow from the battery washing tank is shown at the right in Fig. 7. This overflow carries the water into another tank or cistern outside the building which, in turn, overflows into two other tanks that overflow into the sewer. Thus the sediment is retained in the four settling tanks and is shoveled out at intervals and sold.

Pulling Lead Linings

When it is necessary to pull lead linings from the solid battery crates, the crates are placed on a low bench ad-

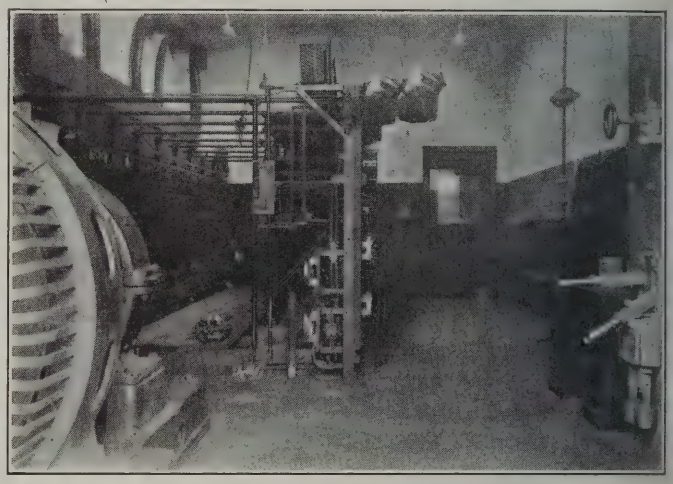


Fig. 9—View of the Switchboard Room

jacent to the washing table and a steam cover applied which just fits the top of the crate.

The tanks are kept full of steam until the compound in which they are set is softened. The battery crate is then held in a vice, one jaw of which is made of a ten-inch air brake cylinder mounted in a horizontal position, while the lead lining is pulled by a small chain hoist fitted with special grips for taking hold of the upper edge of the lead lining.

Cleaning and Repainting Lead Linings

After the lead lining has been removed it is placed in a tank containing a hot solution of caustic soda and is scrubbed with a brush until all of the old paint is removed. Then it is inspected and repainted with acid-proof paint on the stand shown in Fig. 8. The upper platform of the stand is free to rotate and the lining is placed upside down on this and the paint applied with a brush. The larger lower platform is rigid and its purpose is to catch the drip.

The Acid Room

The acid room, located at the east end of the building, is quite elaborate and has several features which are unique. It contains a water still, a distilled water tank, an old acid tank, two diluting tanks, new acid tank, an elevated acid distributing tank and a siphon well. The location of these tanks is shown in Fig. 3. The distilled water tank is placed about five feet above the floor and is fitted with pipe connections so that distilled water can be run into the old acid tank or into either diluting tank.

All of the other tanks have lead pipe outlets in the bottom and inlets at the top. The outlets are carried down into the siphon well where they are fitted with air jet con-

nections and the piping is so arranged that it is possible to pump from any tank into any other. The acid dump tank in the battery-cleaning room is also connected with the siphon well so that the old electrolyte can be drawn from it and pumped into the old acid tank. Here the old electrolyte is tested and reclaimed or discarded. Air jets are also used to mix the acid with the water in the diluting tanks. The acid distributing tank is placed about ten feet above the floor and is connected to the filling spigot at the end of the assembling table in the battery-cleaning room.

Charging Equipment

The switchboard room shown in Fig. 9 is located between the cleaning and charging rooms. Power is supplied by a motor generator set consisting of a 3-phase, 190 hp. 25-cycle, 2,200-volt synchronous motor running at 750 r.p.m. driving a 125 kw., 100-volt direct current generator.

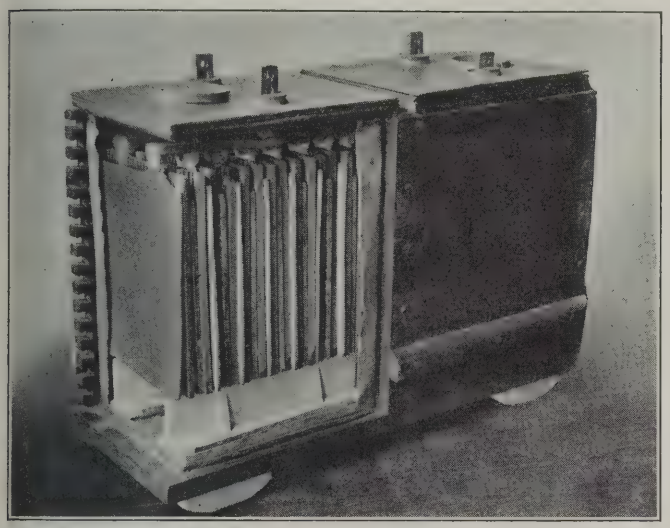


Fig. 10—One of the New Pullman Batteries. Side Cut Away to Show Construction of Cell

One end of the charging panel is shown at the center of the illustration. There are 32 connections to the generator on this board with 32 carbon pile charging rheostats and there are 120 charging circuits to the battery department besides four yard charging lines.

The charging lines are distributed through the battery department in wooden troughs hung about a foot below the ceiling and the ends of the lines are brought out of the bottom of the boxes at convenient intervals through porcelain bushings. These troughs are about 6 sq. in. in cross section and may be seen in Fig. 1. The tops of the troughs are covered with sheet lead which overhangs the sides like the eaves over the side of a building. This completely protects the trough as it has been found that the condensations from the acid fumes in the charging room will form only on the top and not on the sides or bottom of any suspended object.

New Pullman Battery

A new type of lead storage battery has been designed by the Pullman Company to meet its requirements for car lighting service which has a number of features worthy of mention. One of the boxes, cut away to show the interior of one of the two cells is illustrated in Fig. 10. The cells have 15 plates each with a capacity of 350 ampere hours. Wood separators are used with rubber end and side sheets. The bottom rests are 3 in. high and are made of porcelain. The bottom rests in the older type of Pullman batteries were 1¾ in. high and the increased sediment space was decided upon to obviate the necessity of shipping batteries in from points on the road to the repair shops for cleaning. There is a connected load of 75 amperes on most Pullman cars and this usually means from ¾ in. to 2 in. of sediment between shopping periods, depending upon the class of service the car has been in. It is expected that the new batteries will never have to be cleaned between shopping periods. The acid space over the top of the plates has been increased ¾ in.

The increased acid and sediment spaces necessitate a higher crate and this in turn calls for a higher battery box under the car. All new battery boxes will be built in two sections, one under each side of the car with an inside height of 24⅛ in. In this way the weight under the car will be evenly distributed. The old boxes had an inside height of 20⅝ in. Half of the battery will be contained in each battery box.

All open crates will gradually be displaced by solid crates and the crates for the new batteries are made of yellow pine with dovetailed and glued corners, and are fitted with porcelain skids, brass screws also being used for added protection. There is a one-inch space between the two lead linings in each crate to protect against possible short circuit between tanks. The crates are impregnated with paraffin. This is accomplished by immersing them in melted paraffin at a temperature of about 225 deg. F. for from 30 to 45 minutes and then placing them in another paraffin bath at a temperature of 135 deg. F. for from 5 to 10 minutes.

Parts of one of the lead linings and the forms used in assembling these parts are shown in Fig. 11. The lining is made of a sheet of 5-pound lead. This lead, which is about 3 inches longer than the form, is bent around the sheet iron form shown at the left, and the side seam closed with the gas flame lead burner. Two of the plate-rest retainers, one of which is shown leaning against the form, are then placed in the slots at the top of the form. Then the corners, which extend above the form, are V'd out with a pair of shears, the sides which extend above the form are bent down, the small rectangular piece of sheet lead placed on top of the form in the center and all of the seams filled by the lead burner. The operation of closing the bottom seams secures the plate-rest retainers in position. The last operation is to place the crown,

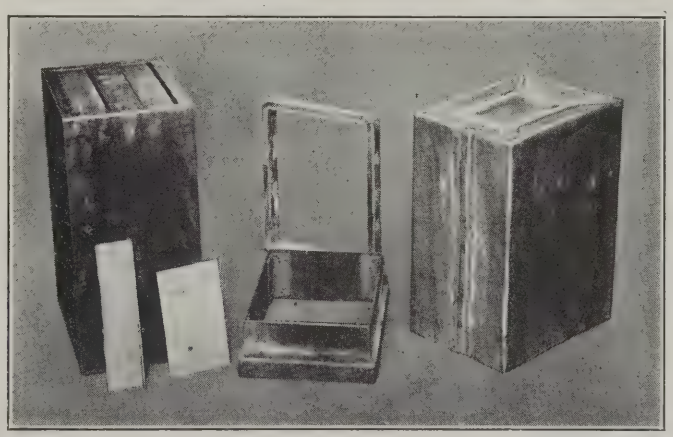


Fig. 11—Parts of One of the Lead Linings and the Forms Used in Assembling Them

shown at the rear over the smaller form shown in the center. With the crown in place and the tank down over the form until it bears against the crown, the two are burned together. The depth of the slot in the crown is one inch. The crown slot on the battery shown in Fig. 10 is less than one inch and is not standard.

The covers are made of antimonial lead and have a lip on the outer edge which extends down into the slot of the crown on the lining. The groove in the crown is filled with an asphaltum or bitumen compound which is always plastic and has a melting temperature of not more than 150 deg. F. This makes it possible for the plates to grow enough, to lift the cover without breaking the cover seal and the seal will not be broken by vibration or rough handling. The terminals are insulated from the cover by soft rubber bushings and there is an unusually large round vent hole with a loose flanged lead cover. There is an inner and an outer flange on the vent hole cover, the inner flange extending well down into the hole. The hole is tapered and has a diameter of 3⅛ in. at the top and 2⅝ in. at the bottom. The purpose of the large hole is to facilitate flushing and inspection.

Before the lead lining is placed in the crate it is painted. Then it is placed on a form, the crate partly filled with hot compound and the lining pushed down to the bottom, enough compound having been used so that it will overflow on all sides. A piece of roofing paper is put in the bottom of the crate under the lead lining to keep the lining from coming into actual contact with the wood. The space between the crown and the top of the wood crate is filled with compound having a melting temperature of 225 deg. F.

New 60-Ton Electric Locomotive for Tidewater Southern

THE Tidewater Southern, a subsidiary of the Western Pacific, has recently placed in operation a 60-ton electric locomotive which embodies several interesting features. The present electrified section of the Tidewater Southern is arranged for 1,200-volt operation that will be changed over to 1,500 volts in the near future. The new locomotive was designed for operation at the higher voltage in view of the contemplated change in potential and will be used for handling the increased interurban freight traffic in the San Joaquin Valley, between Stockton and Thurlock, California.

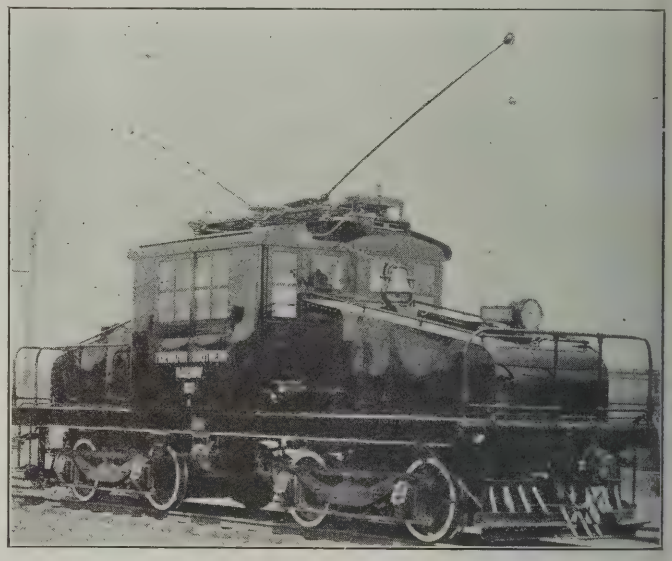
The locomotive is 37 ft. 4 in. long; 9 ft. 7 in. wide, with a total wheelbase of 25 ft. 5 in. All of its weight is carried on the driving axles. The cab has the sloping end steeple type of construction, extending practically the whole length of the underframe, which consists of four steel channels extending the entire length of the platform. The bolsters are built up of 1 in. steel plates, 10 in. in width, riveted to all four longitudinal sills.

The drawhead casings are bolted to the center sills, which are in turn riveted to the end frame. The draft gear consists of MCB couplers with 5 in. by 7 in. shank, standard twin springs and follower plates. The whole platform is floored, and the structural steel frame is stiffened by brace plates and a steel floor which extends the width and length of the locomotive.

The side frames of the two four-wheel trucks are built of heavy rolled bars for the top and bottom member with cast steel pedestals. The bolster or center transom is bolted rigidly to the side frames, and the entire weight of the truck, as well as that of the superstructure, is carried by semi-elliptic springs hung by links to the double side equalizer bars, which rest on the journal boxes. The journals are of standard design with MCB bearings and wedges. The wheels are of solid rolled steel, 36 in. in diameter, with MCB treads and flanges.

The locomotive is driven by four 750/1,500-volt, box frame, forced ventilated railway motors through a single reduction gear of 69.17 ratio. The motors are arranged for shunted field operation, which gives a continuous rating on 1,500 volts of 14,500 lb. continuous tractive effort at 22 miles an hour. It will operate at reduced speed on 600 volts. The type M single unit control is used with two master controllers giving ten steps with four motors in series and seven steps with two in series. The motors are permanently connected in groups of two in series.

The motor rheostats, and various parts of the control equipment, are housed under the sloping ends of the cab.



Electric Freight Locomotive Designed to Operate from 1500-Volt Trolley

Current is collected by two pole trolleys which will operate through a range of from 14 ft. to 22 ft. above the rail. There is a main switch with a magnetic blowout for opening the main circuit in emergency, or for inspection, and a number of auxiliary switches for the control of headlights, cablights, dynamotor blower set, compressor and compressor relay, control circuits, heaters, field shunting and control transfer. Headlights, as well as cablights, control and compressor relay, are operated from the dynamotor, except when the locomotive is being run on 600 volts, when they are operated from the trolley. There are two air compressors with a combined piston displacement of 70 cu. ft. per minute when delivering air at 100 lb. per sq. in. pressure. Air is used for sanders, bell ringer, and control, in addition to the air brakes.

The new grade crossing law of Michigan requires that signs at least 24-in. in diameter shall be placed 500 to 600 ft. from every crossing, the State Highway Department furnishing the signs. The law further requires that all crossings shall be smooth and even and 16 ft. wide for a distance of 25 ft. on each side of the crossing.

Principles of Car Lighting By Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

XIV. E. S. B. Car Lighting Equipment

THE E. S. B. Car Lighting Equipment consists of a generator, driven by a belt from the car axle, a generator regulator panel, which is mounted in a suitable cabinet inside of the car, and a storage battery, which is suspended in a box under the car body.

The fundamental principle of the E. S. B. axle system is constant voltage, that is, the voltage of the dynamo is held constant at a point just above the floating voltage of the battery. The dynamo, therefore, controls the voltage maintained at the battery terminals instead of the battery determining the dynamo voltage as in other types of axle equipments. It is also interesting to note that this equipment does not include a lamp regulator, and that the movable parts are confined to the automatic switch on the regulator panel and the armature within the generator.

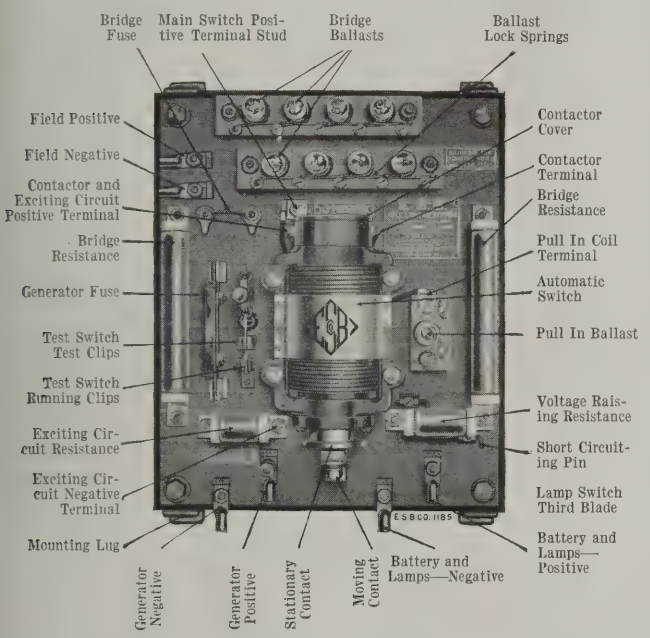


Fig. 1—Generator Regulator Panel

The lamp regulator is eliminated by using 32-volt lamps, 15 cells of battery, and maintaining a voltage of approximately 33.5 volts at the switchboard.

The voltage at the lamps, is, therefore, so nearly normal that no further regulation is required.

Generator

The generator, Figs. 2 and 4, consists of the following parts:—magnet frame, bearing brackets, pole shoes, field coils, armature and commutator, brush holders and brushes, cover bell and four terminals. Note that the generator is constructed to obviate the necessity of dismantling the machine in order to renew any of the leads from the generator to the junction box on the car body.

The magnet frame is a solid casting of high grade magnetic steel with two internally projecting cylindrical pole cores. For the truck type machine, four feet are cast on the frame, which are solidly clamped to the suspension loop bars by means of two clamp bars. The body type machines are provided with two suspension lugs cast on the frame at the top and bored to receive a tubular steel bearing bushing through which passes a 1¾ in. steel bar supported from the suspension carriage. Lubrication is provided by a grease cup mounted on the bushing, with suitable grease reservoir.

The bearing brackets on either end are substantial castings, that at the commutator end comprising four arms for supporting the ball bearing housing, between which ample spaces afford easy access to the brushes.

The pole shoes are of laminated iron riveted together and held in position by bolts passing through the pole cores. End laminations are spot welded for rigidity.

The field coils are solid impregnated and protected by heavy duck washers, while a steel spring plate between the coil and the frame prevents any motion or loosening and consequently chafing.

The armature and commutator are assembled on a separate quill. The armature is a bipolar wound on a core formed of special non-aging high grade laminations, the outer ones spot welded. The coils, Fig. 6, are form wound, accurately shaped, and the leads securely sweated into the short solid risers of the commutator bars.

Commutator bars are of hard drawn copper, separated by best quality mica, undercut with rounded edges after assembly.

The brush holder yoke is in the form of a ring clamped over the ball bearing housing and the complete brush rigging with brush holders in place can be slipped off after disconnecting leads and loosening the clamp bolt and set screw without dismantling any other part of the machine. See Fig. 3.

The brush holders are simple in construction, permitting easy inspection, and are designed to maintain strictly radial pressure on the brush with no tendency to rock and produce a different contact surface for each direction of rotation.

The conductor for connecting the "short circuit" brushes is mounted on the brush holder ring, and a suitable fuse is inserted in this conductor.

A cover bell of pressed steel, held in place by two swivel bolts and heavy wing nuts, incloses the commutator end of the machine. Fig. 3. Four terminals, two

main terminals and two field terminals, are brought out through the frame of the machine into a terminal box, where detachable connections are made to the flexible conductors passing through a suitable outlet in the tightly fitting terminal box cover, adapted for hose connection.

The box is reversible in the case of the body hung generator so that the leads may be brought out from either side of the generator.

The following table gives the characteristics and principal dimensions and weights of the E. S. B. axle lighting generators:

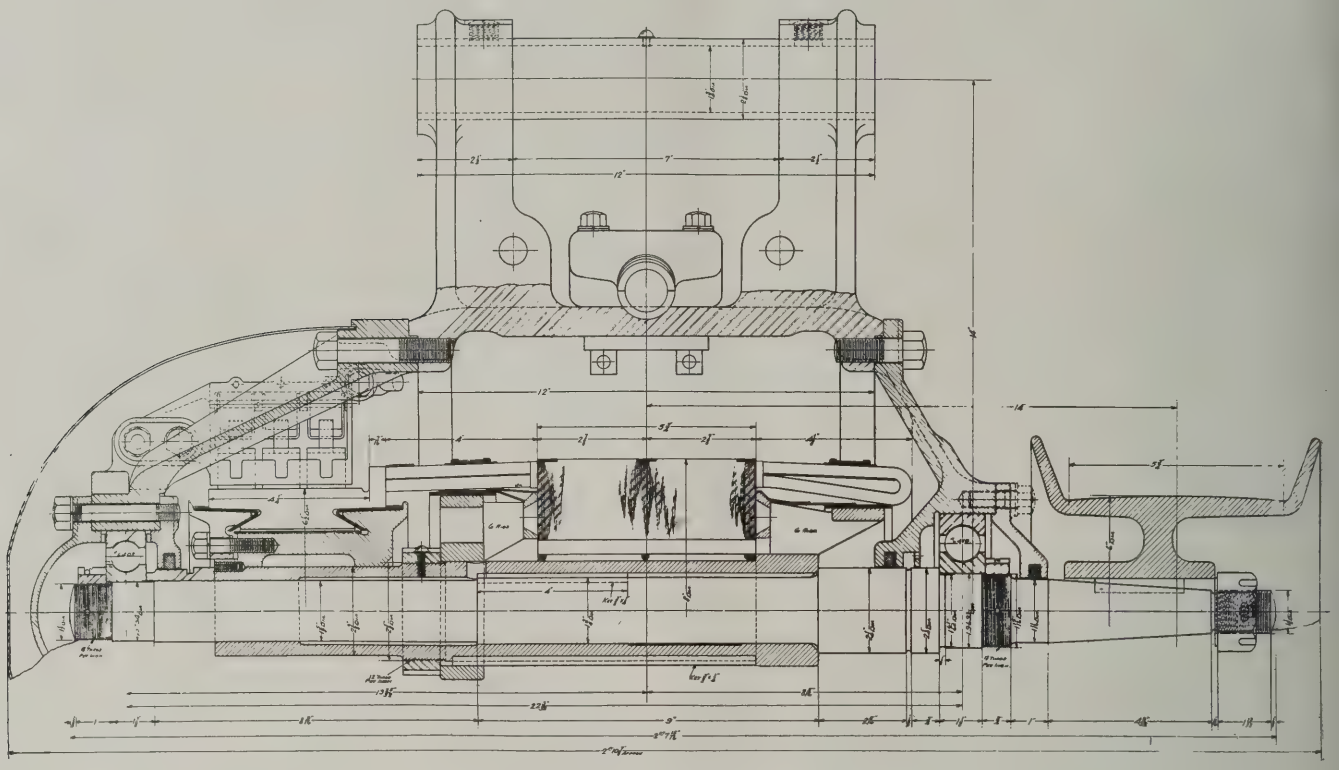


Fig. 2—Cross Section of Train Lighting Generator. Body Hung Type

	2 Kw. Truck Type	3 Kw. Truck Type	3 Kw. Body Hung
Continuous capacity	50 amps.	75 amps.	75 amps.
Overload capacity, 2 hrs.	65 amps.	100 amps.	100 amps.
Outside diameter, including feet	17 ins.	17 ins.	15½ ins.
Length overall without pulley	33 5/16 ins.	34½ ins.	33⅞ ins.
Weight total without pulley	490 lbs.	510 lbs.	440 lbs.
Weight armature without ball bearing	155 lbs.	165 lbs.	150 lbs.
"Cut in" speed (with 15 cells) R. P. M.	300	425	475
"Full load" speed R. P. M.	490	625	650

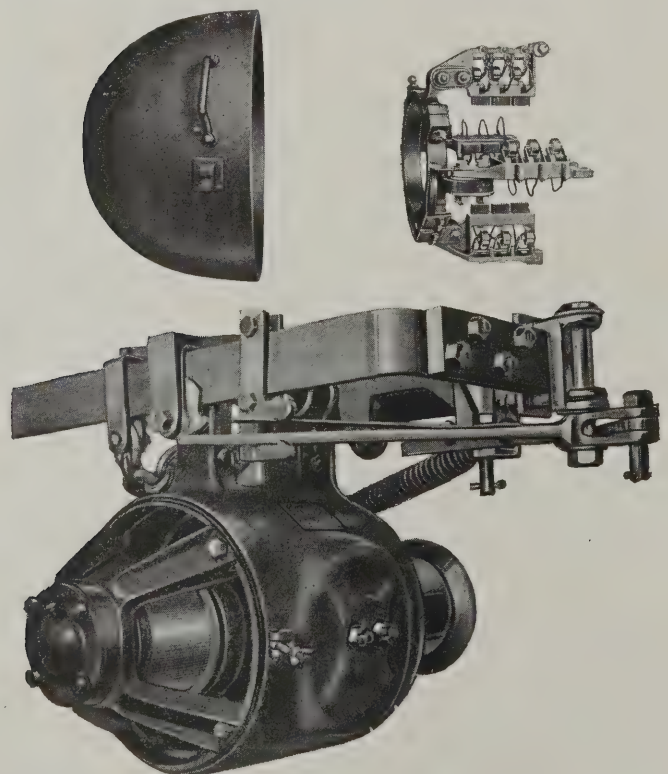


Fig. 3—Type D-3 Generator With Brush Rigging and Cover Bell Removed Showing Body Hung Suspension Arrangement

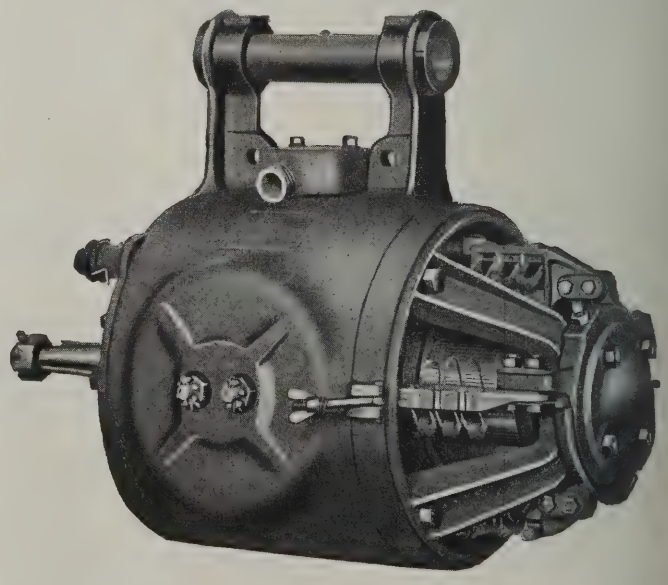


Fig. 4—Generator Showing the Supporting Bushing

Generator Regulator

The generator regulator, Fig. 1, consists of a slate panel on which are mounted the resistances for the Wheatstone bridge control, a test switch, the automatic switch and the generator and field fuses. This panel measures 15 in. by 18 in. and weighs 75 lb.

The resistances for the Wheatstone bridge control consist of two fixed resistance units, one in each end of the two opposite branches of the bridge, and eight iron ballasts, four in each of the other two branches of the bridge.

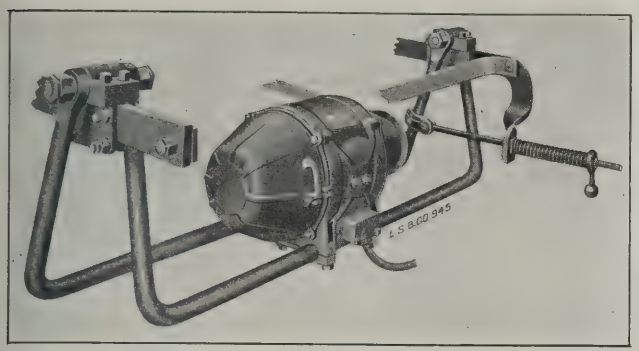


Fig. 5—Truck Type Suspension

The iron wire "ballast" resistance units consist of iron wire filaments enclosed in glass bulbs filled with hydrogen mounted on an elongated Edison base. These are secured in place in socket plates provided with steel spring locks which prevent the ballasts from becoming loose under vibration.

The test switch is a special spring-retained double throw type. The automatic switch is of the solenoid type consisting of a steel frame which supports three coils. Within these coils a cylindrical plunger with conical top is free to move vertically with minimum friction. This plunger carries below, the moving contact, in the form of a laminated brush connected by a substantial flexible conductor to a terminal stud on the board. The fixed contact consists of a copper ring moulded into a support of high grade moulded insulation attached to the lower side of the switch frame. On top of the automatic switch a cylindrical projection of the switch frame surrounded by an exciting coil in series with the main switch shunt coil acts on a spring-supported armature to close the circuit of the pull-in coil.

This contactor is enclosed in a ring of high grade moulded insulation provided with suitable metallic inserts for terminal connections, with cover of same material.

Two of the terminal studs, one on either side of the main fuse, are made extra long to permit connecting an ammeter in the generator circuit, the fuse there being removed after the instrument is connected.

Each piece of apparatus on the regulator panel may be removed without disturbing the connections and without access to the back of the board. Every stud bolt passing through the board is locked at the back so that it cannot turn when nuts are removed or replaced in front.

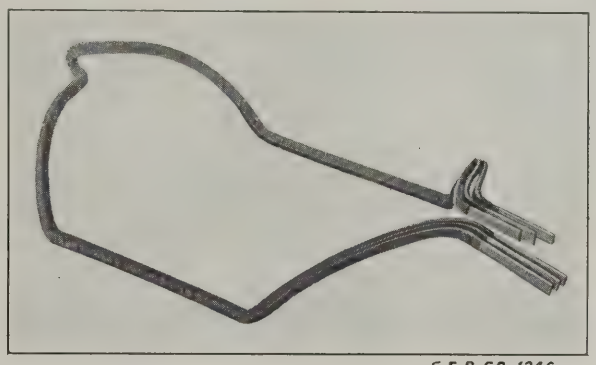


Fig. 6—Armature Coil, Insulated. Three turns are Taped Together in One Bundle

Body Suspension

The E. S. B. Body Hung Type Suspension is so constructed that belts can be easily applied. The belt tension is practically constant throughout the permitted swing of the generator on the suspension shaft. Ample provision is made for lining up the generator with the car axle. The generator is hung from a cast steel carriage which may be moved longitudinally on its supports by means of a hand lever (which has replaced the screw adjustment formerly used). Suitable wedges or clamps are attached to the carriage for holding it securely in place on the hanger. The tension spring, when extended to its maximum, has a pull of only about 250 lb., which is a con-

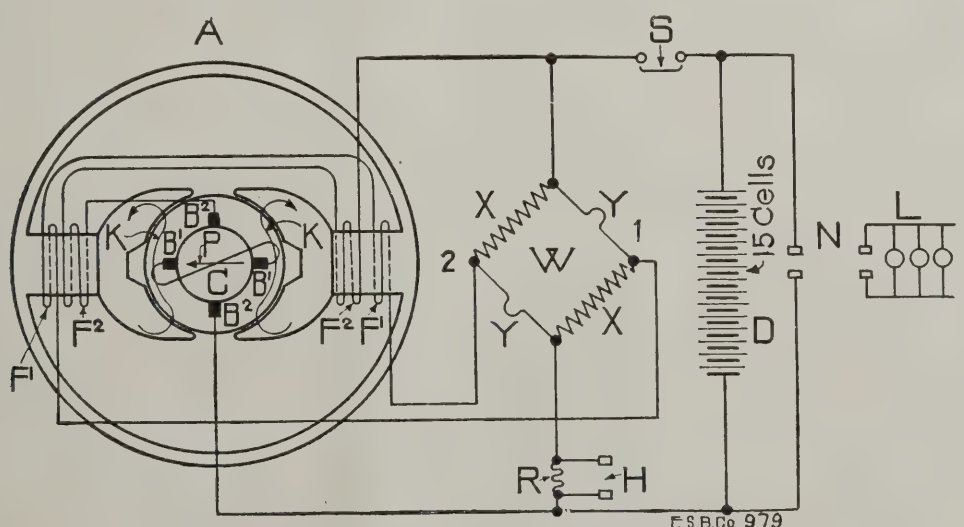


Fig. 7—Diagram of Circuits

siderable factor in prolonging belt life. This suspension is shown in Figs. 3 and 9, and consists of a cast steel suspension carriage, supported on two horizontal bars, *A*, along which it may be moved by means of a hand lever toward or away from the truck. The belt tension spring is fastened at one end to the frame of the machine and at the other end to the suspension carriage. The belt tension is therefore applied or released by moving the suspension carriage away from or towards the truck by means of the hand lever. This lever is connected to the suspension carriage by a loosely pivoted link, whose effective length may be adjusted by reason of a series of holes at one end. In this way a quick adjustment may be made to provide for any stretch of the belt or for shortening when a piece is cut out, and the proper belt tension may be maintained. In the running position the hand lever is held in position by a spring latch. Furthermore, the suspension carriage is firmly clamped to the horizontal bars by means of two rotary clamps whose clamping action may be applied or released by the tap of a hammer. The horizontal bars which support the suspension carriage are clamped at one end to a transverse supporting bar by means of vertical clamping bolts, permitting the dynamo to be properly aligned.

Truck Suspension

The E. S. B. Truck Type Suspension, Fig. 5, is the original "two-point" suspension designed to maintain permanent belt alignment and insure maximum belt life, and has successfully withstood the test of the severest service. The feet of the dynamo are rigidly clamped to the loop bars, there being no wear at these points. All wear is confined to the ample surface of two bearing pins free to rock in tubular steel bushings carried by the bearing saddles. This type suspension is shown in Fig. 5 and it will be noted that the dynamo feet are clamped and locked solidly to the loop bars so that there is no wear in the feet of the machine. The loop bars at either end are clamped to the opposite ends of the large bearing pins, the pins being free to turn in tubular steel bushings clamped in the bearing saddle. Each pin provides a bearing surface 4½ in. long by 1¾ in. diameter. The bearing saddles are adjusted longitudinally on the side bars, which project from the truck frame. The bearing saddles are bolted and locked securely on the side bars. It will be seen from the above that there are only two wearing parts to the suspension and these consist of tubular steel bushings having large bearing surfaces, which are easily and cheaply renewed. A grease cup is mounted on one end of each bearing pin by which suitable lubrication is secured.

Theory

The E. S. B. generator is of the Rosenburg type whose main field is produced by a magneto-motive-force developed by the armature winding. It is illustrated diagrammatically in Fig. 7, and consists of a bipolar armature rotating between two heavy pole shoes, each shoe being connected securely to the frame of the machine by bolts passing through the pole cores. The pole cores are of small cross-section compared with the ordinary dynamo. Two pairs of brushes bear upon the commutator spaced 90 degrees apart, one pair being short-circuited, while the other pair is connected through the series winding to the external circuit. These brushes are designated respectively "short circuit brushes" and "load brushes."

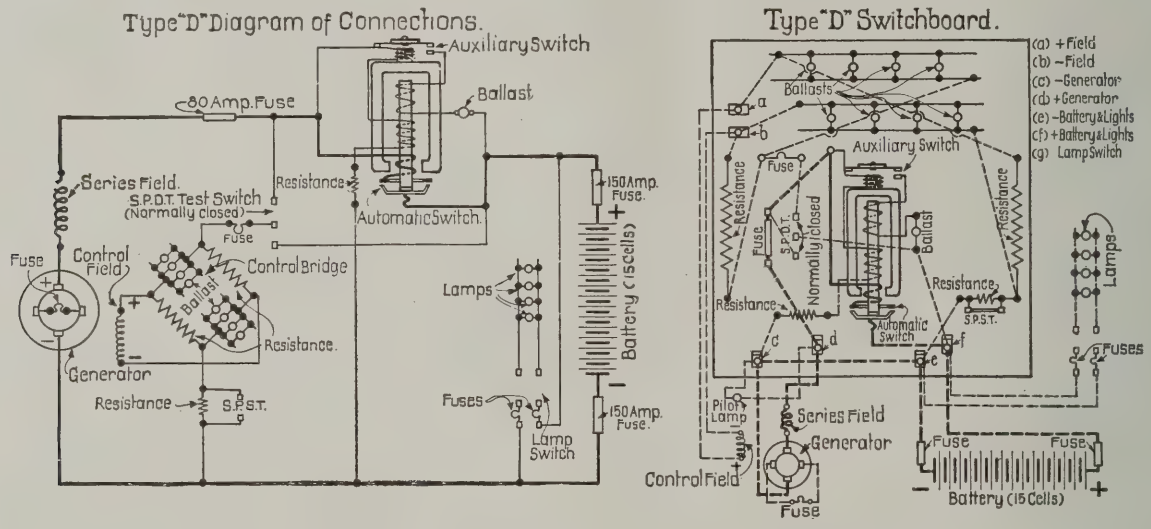


Fig. 8—Showing Type D Diagram of Connections and Type D Switchboard

On the pole necks are two field windings, F^1 and F^2. The series winding F^2 is connected between the top load brush and the generator terminal. The control field winding F^1 is connected across the Wheatstone bridge W and provides the primary field excitation controlling the voltage of the dynamo.

The magnetic field produced by this primary excitation passes across the armature in the direction of the arrow P and then through the pole shoes, pole necks and the frame of the machine. This magnetic field is, under normal conditions, of very small strength, producing a low voltage between the short circuit brushes B^1. This low voltage, however, produces a sufficient flow of current through the short circuit between these brushes and through the armature winding to develop a considerable magneto-motive-force. This latter magneto-motive-force produces a magnetic field at right angles to the primary field, which passes through the armature and pole shoes as shown by the arrows K, but which does not pass through the pole cores or frame of the machine. This secondary field flux produces the desired voltage across the load brushes B^2.

One of the principal results obtained with the Rosenburg type of machine is the development of the same polarity for either direction of rotation without employing any pole changer, or any alterations whatever in the circuit connections. This is due to the fact that when the direction of rotation changes, the voltage generated across the short circuit brushes by the primary field is reversed and the current flowing between these brushes is, therefore, reversed in direction. This reverses the direction of the secondary field K, which produces the voltage across the load brushes B^2. It will be seen, therefore, that when the direction of armature rotation is reversed the direction of the main or secondary field excitation is also reversed, so that the polarity remains the same.

The E. S. B. Dynamo is controlled for constant voltage rather than constant current, the voltage being held at approximately 33½ volts when used with 15-cell equipments. This control is effected by means of a Wheatstone bridge W, connected across the machine terminals at two opposite junction points of the bridge, while the other two opposite points are connected to the field terminals. The Wheatstone bridge consists of two fixed resistances, XX, and two wire "ballast" resistances, YY. The iron wire "ballast" resistances have the characteristic of increasing their resistance rapidly with very small increments of current when operating at a dull red heat. The design of this bridge (for 15-cell equipments) is such that when the machine voltage is 33½ volts the resistances of X and Y are practically equal. Under these conditions no current will flow through the field winding, F^1. When the voltage is lower than 33½, the resistance of Y is less than the resistance of X, and Y will therefore carry more current than X, the excess current flowing through the field winding F^1. As the voltage of the machine increases, therefore, the field excitation becomes smaller and smaller, approaching zero as the voltage approaches 33½ volts. At high speed the current in the field is actually reversed in order to partly counteract the residual magnetism in the pole necks and the frame of the machine. In series with the Wheatstone bridge is a fixed resistance R which is normally short-circuited by a copper rod H clamped between two binding posts. This is the normal position of the rod H. When this short circuit is opened by sliding the rod H out of contact with one of the binding posts, the drop in the resistance R lowers the voltage applied across the Wheatstone bridge, and in order to restore the latter to its normal balanced value, the voltage of the machine will be increased by an amount equal to the drop in the resistance R. The principle use of this device is to restore the voltage to normal in case of an open circuit in one of the bridge ballasts, if a renewal ballast is not immediately available.

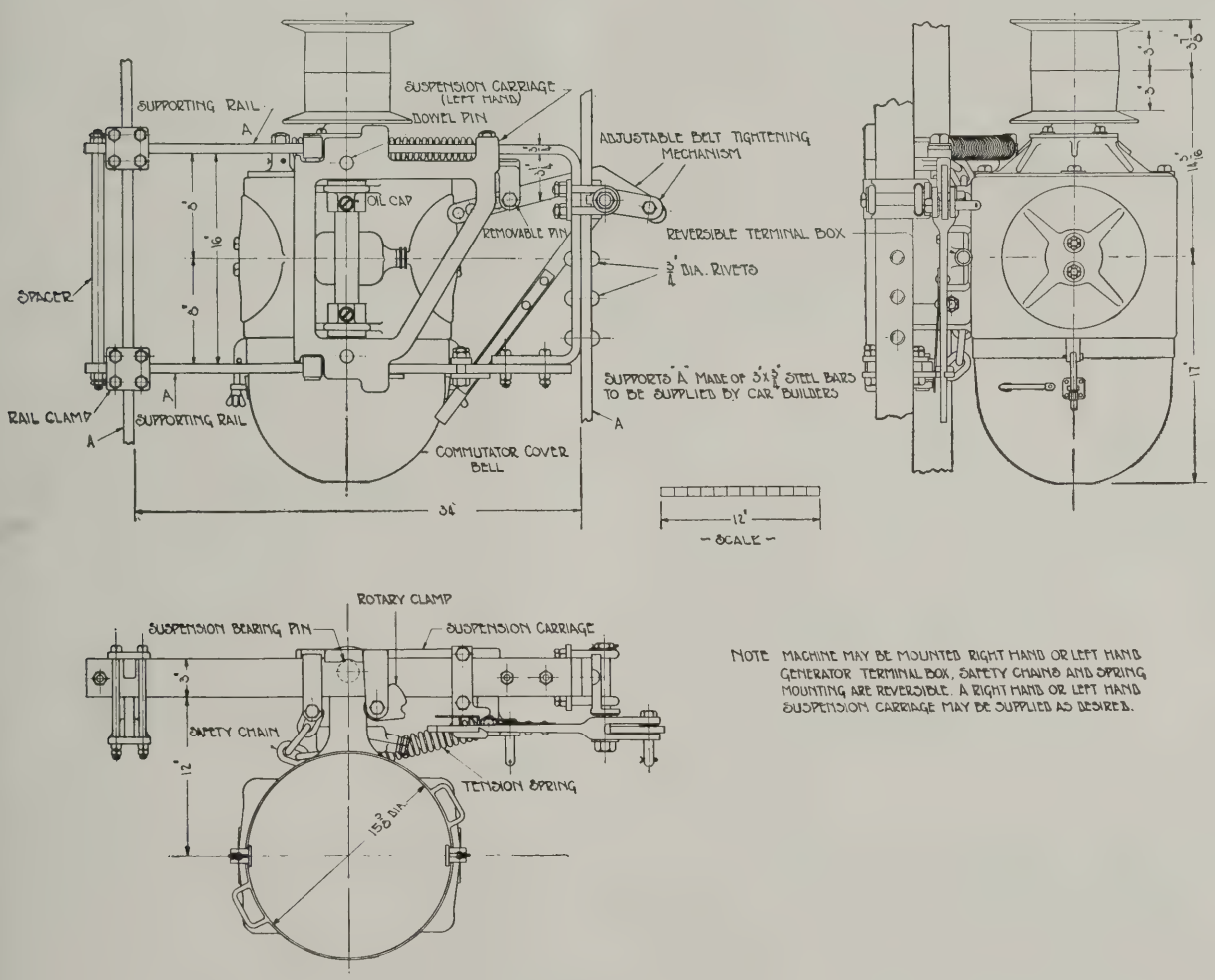

SUPPORTING RAIL
SUSPENSION CARRIAGE (LEFT HAND)
DOWEL PIN
ADJUSTABLE BELT TIGHTENING MECHANISM
OIL CAP
REMOVABLE PIN
REVERSIBLE TERMINAL BOX
¾" DIA. RIVETS
SPACER
SUPPORTS "A" MADE OF 5"x¾" STEEL BARS TO BE SUPPLIED BY CAR BUILDERS
RAIL CLAMP
SUPPORTING RAIL
COMMUTATOR COVER BELL
SCALE
ROTARY CLAMP
SUSPENSION BEARING PIN
SUSPENSION CARRIAGE
SAFETY CHAIN
TENSION SPRING
NOTE MACHINE MAY BE MOUNTED RIGHT HAND OR LEFT HAND GENERATOR TERMINAL BOX, SAFETY CHAINS AND SPRING MOUNTING ARE REVERSIBLE. A RIGHT HAND OR LEFT HAND SUSPENSION CARRIAGE MAY BE SUPPLIED AS DESIRED.

Fig. 9—Body Hung Suspension

Fig. 11 shows the constant voltage characteristics of the dynamo when operating with the E. S. B. Wheatstone bridge control at various speeds. Two curves are given, one corresponding to no load, and the other correspond-

ing to full load on the machine, the latter showing a higher voltage to compensate for line drop.

The E. S. B. dynamo is so designed as to protect itself automatically against excessive overloads. This result is accomplished by designing the machine to take advantage of saturation in the pole necks due to leakage flux, caused by the opposing effects of the series field and the armature reaction, and is inherent in the design of the machine and not dependent upon any automatic regulating devices. This characteristic is independent of speed and is shown on the characteristic curve, Fig. 12, which gives the volt-

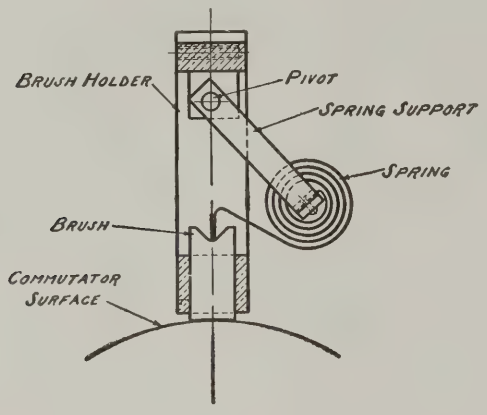


Fig. 10—Constant Tension Brush Holder

age of the machine at various loads. It will be seen that the machine is slightly over-compounded to take care of drop in wiring up to approximately full load, at which point the voltage begins to drop with further increase of load. The result of this dynamo characteristic in its effect on the charging current into the battery is shown in Fig. 13, in which two curves are given, curve *A* showing the charging current which would be put into a partly discharged battery if strictly constant voltage were maintained at its terminals, while curve *B* shows the input

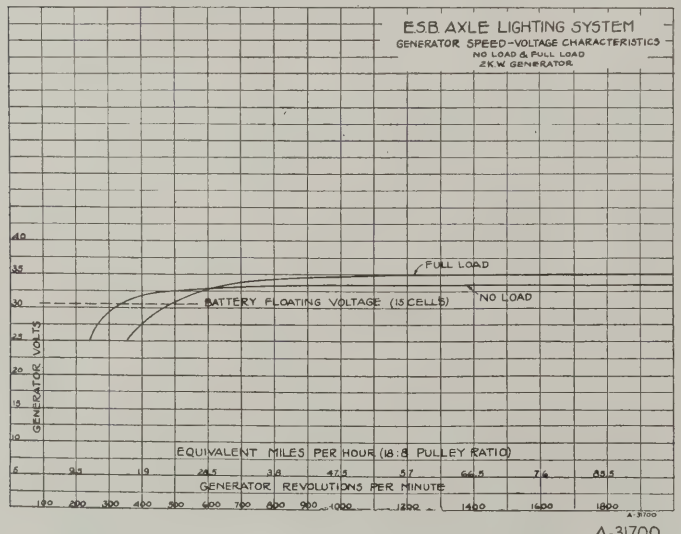


Fig. 11—Constant Voltage Characteristics

from E. S. B. dynamo designed to protect itself against excessive overload, as described above. It should be noted that this curve *B* applies to the 2 kw. machine, while the corresponding curve for the 3 kw. machine is proportionately higher.

Control Panel

The dynamo control panel is shown in Fig. 1, while in Fig. 8 will be found the diagram of connections at the left and the actual switchboard connections at the right. On the panel are mounted the resistances for the Wheat-

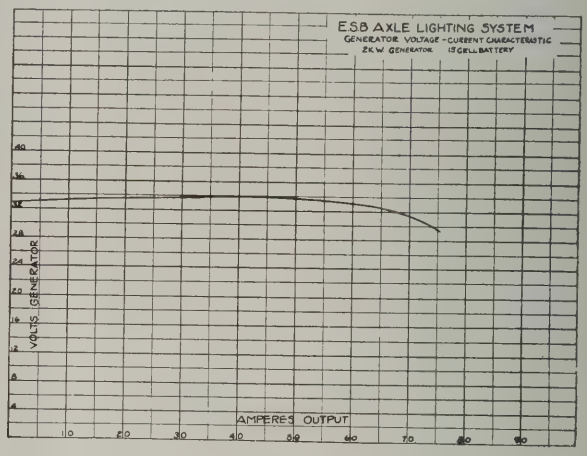


Fig. 12—Voltage at Various Loads

stone bridge control consisting of two fixed resistance units, one in each of two opposite branches of the bridge, and eight iron wire ballasts, four in each of the other two branches of the bridge; also a special spring retained double throw test switch which normally connects the positive generator terminal to the positive junction point

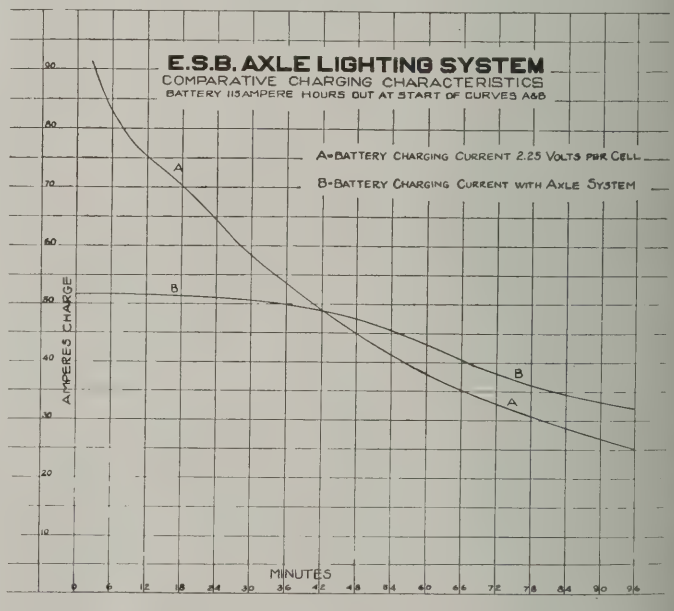

E.S.B. AXLE LIGHTING SYSTEM
COMPARATIVE CHARGING CHARACTERISTICS
BATTERY 115 AMPERE HOURS OUT AT START OF CURVES A&B
A-BATTERY CHARGING CURRENT 2.25 VOLTS PER CELL
B-BATTERY CHARGING CURRENT WITH AXLE SYSTEM
AMPERES CHARGE
MINUTES

Fig. 13—Showing Output at Constant Potential and at Modified Constant Potential as Result of Compounding

of the bridge and is retained in this position by a small helical spring. By pushing the switch handle up against the force of the spring, the bridge positive is disconnected from the dynamo and connected to the battery positive, and since the negative bridge connects the common junction between the battery and the dynamo, this arrangement permits sending a current through the bridge from the battery when the car is standing. This current applied to the bridge for a few seconds will heat the ballasts and fixed resistances, enabling the inspector to determine that they are all in operative condition.

The automatic switch is provided with three coils wound about the plunger portion: the shunt coil, the "pull-in" coil and the series coil. The shunt coil is not of sufficient strength to close the automatic switch at normal voltage, but requires the assisting magneto-motive-force furnished by the "pull-in" coil. The "pull-in" coil is connected between the dynamo positive terminal and the battery positive terminal whenever the dynamo voltage exceeds approximately 20 volts. The "pull-in" coil circuit is dependent upon the closing of a contactor which is located on the top of the automatic switch. The magnetizing coil for the contactor is connected in series with the automatic switch shunt coil and its excitation therefore is proportional to the generator voltage. When the circuit of the "pull-in" coil is closed by this contactor, its excitation opposed the main shunt coil when the dynamo voltage is less than that of the battery. When, however, the voltage of the dynamo exceeds that of the battery by approximately one volt, the current in the "pull-in" coil is in the direction to co-operate with the main shunt coil to close the switch. The closing of the switch is therefore determined by the difference in voltage between the dynamo and the battery and when the battery voltage is low the switch will close sooner than when it is high.

When the dynamo voltage falls below approximately 20 volts, the contactor opens the "pull-in" coil circuit, thus preventing any flow of current from the battery back through this circuit via the dynamo armature when the car is standing. Thus, when standing there is absolutely no current taken from the battery other than that required for the lighting system.

The difference of voltage required to close the automatic switch is so small that not the slightest flicker can be observed in the lights when it closes; since the main coil acting alone is not sufficient to hold the switch closed, it will open with no appreciable reversal of current, and therefore without contact arcing and without flickering of the lights as the dynamo drops in speed.

On the lower part of the panel, at the left, is a fixed resistance in series with the shunt winding of the automatic switch. This resistance is unaffected by change of temperature and serves to limit the effect of temperature changes on the operation of the switch.

On the lower part of the panel, at the right, is the voltage-raising resistance unit and the rod for short-circuiting this is mounted directly beneath the unit.

The fuse to the left of the automatic switch is connected in the positive circuit of the generator. It is mounted on a removable insulating base provided with copper terminals for insertion in the fuse clips.

Characteristics of the E. S. B. Equipment

The E. S. B. constant voltage system eliminates excessive overcharge and this in turn eliminates excessive gassing, see Fig. 14, when the battery is either partially or totally discharged, it is recharged at a rapid rate. This rate, however, tapers off as the battery fills up, in such manner as to keep just below the gassing point; until, when the battery is full, the current input is reduced to a low trickling charge sufficient to keep the cells fully charged, but insufficient to injure the plates even if maintained indefinitely.

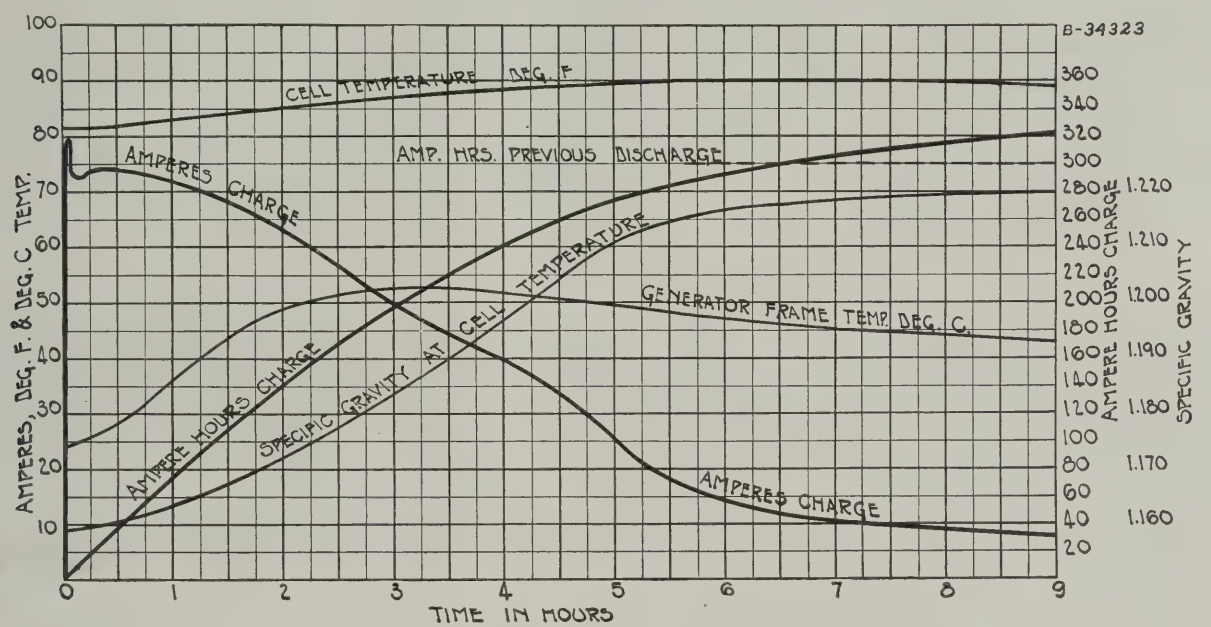


Fig. 14—Curve Showing How Charging Rate Tapers Off as the Battery Fills Up, in Such a Manner As to Keep Just Below the Gassing Point.

By referring to Fig. 14 note that it took but 6½ hours to restore the 300 ampere hours taken out of the battery before charging began. This was without gassing the battery and hence at a high rate of efficiency. At the same time it should be noted that during the first two hours the battery received 140 ampere hours charge at a time when it was most needed, in order to get the battery in operative condition as quickly as possible. This feature, namely, a high charging rate after any discharge and regardless of the state of charge, is what makes the equipment so efficient on short suburban runs.

Note how, after the second hour, the specific gravity and ampere hour curve closely paralleled each other and that the charging rate of the battery decreases as these curves rise.

The generator temperature curve reaches its maximum after three hours' continuous running. This maximum would, of course, be considerably less under intermittent

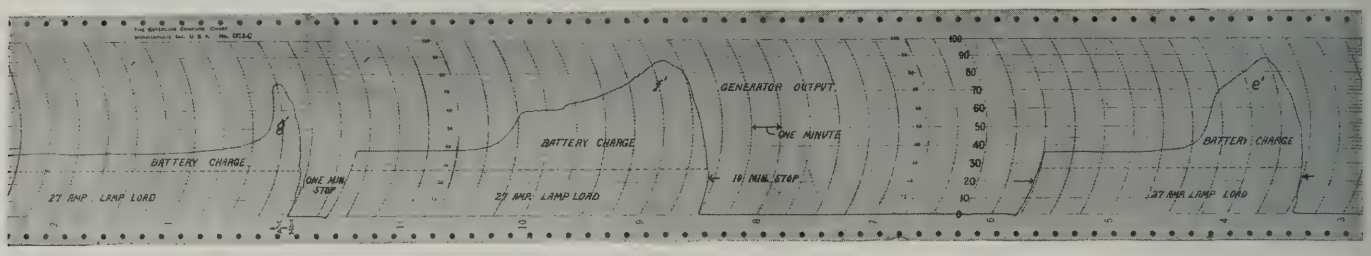
operation, such as is experienced on a train. It gives a good idea of the conservative rating of the generator and shows its ability to take care of any extra load, such as lamps, that might have been turned on at any period of the charging.

The graphic charts, Fig. 15, show a characteristic of constant potential charging that is worthy of note. No doubt many storage battery operators now realize how rapidly and efficiently, and with what beneficial results storage batteries may be charged with constant voltage methods and are familiar with the general characteristics of such a charge starting with a fully discharged battery, but few men are informed regarding the results obtained with such charges considering batteries which have only been partially discharged. The graphic charts, Fig. 15, shows the advantage of constant potential charging in car lighting service, especially in a service involving frequent stops.

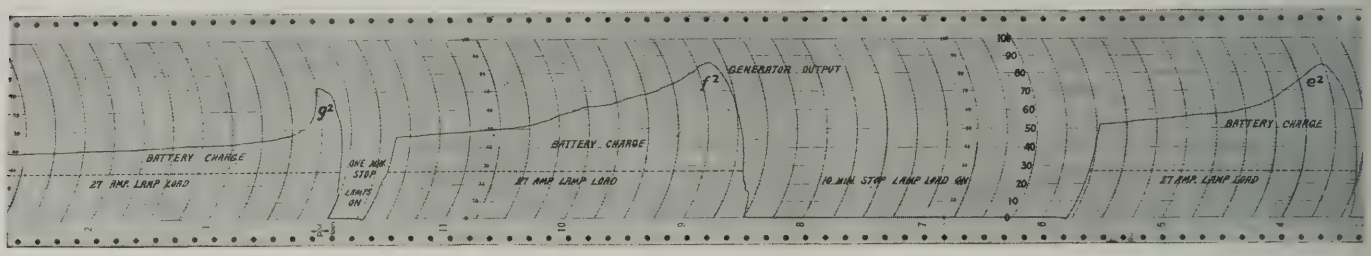
This equipment does not require a pole changer as the dynamo builds up with the same polarity for either direction of rotation, without any external change of connection.

Another characteristic is that no sneak current is taken from the battery when the equipment is standing with lights turned off, since every circuit on the control panel and dynamo is automatically disconnected from the battery when the car stops.

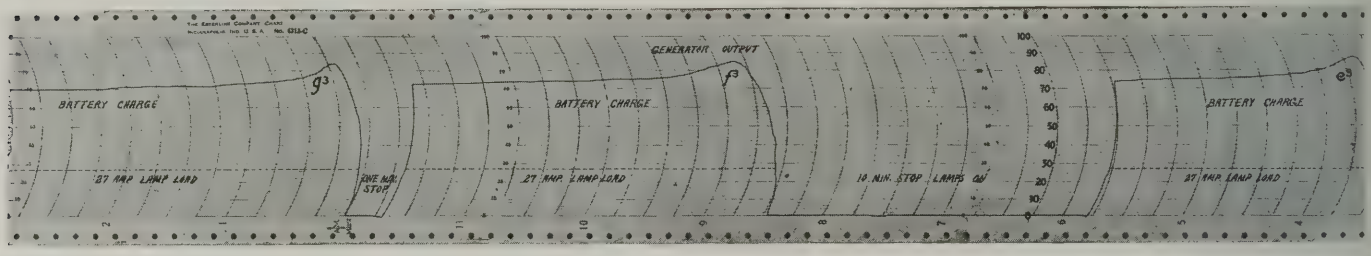
Another feature is that, should the polarity of the bat-



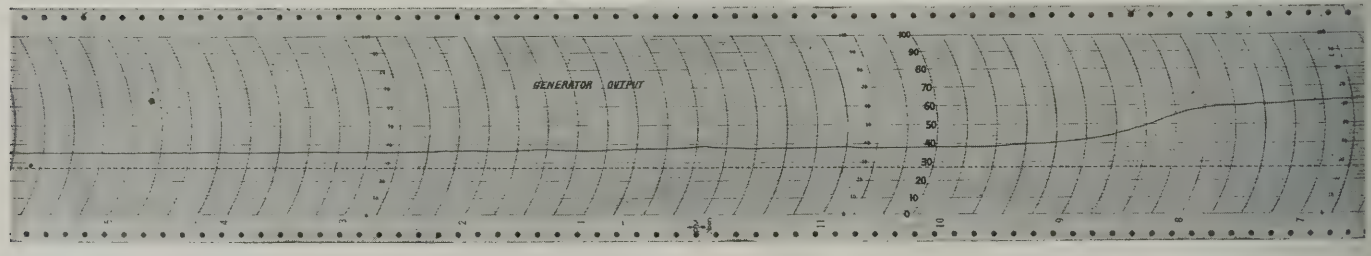
(A) At the beginning or right hand end of the curve the start is made with a full battery (lamp 27 amp. plus battery 3 amp.), total generator output immediately tapering down. It will be observed that the current taken out of the battery at the two minute stop is quickly restored through the high longer period than at a^1 after the two minute stop. The same is noticeable after the ten-minute stop at f^1. Note the difference between g^1 and a^1 one



(B) Is a duplicate of the run, shown on curve (A), except that the battery was discharged at 27 amps. for one and a half hours before starting up. Compare



(C) Shows the same runs and stops except that the battery was discharged

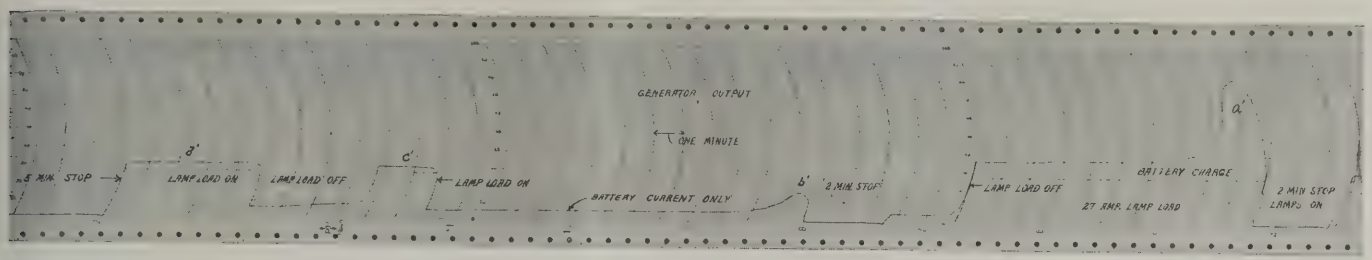


(D) Shows a continuous run with a 27 amp. lamp load, after a thirty-minute stop had discharged 13.5 amp. hour. Note that current taken out was put

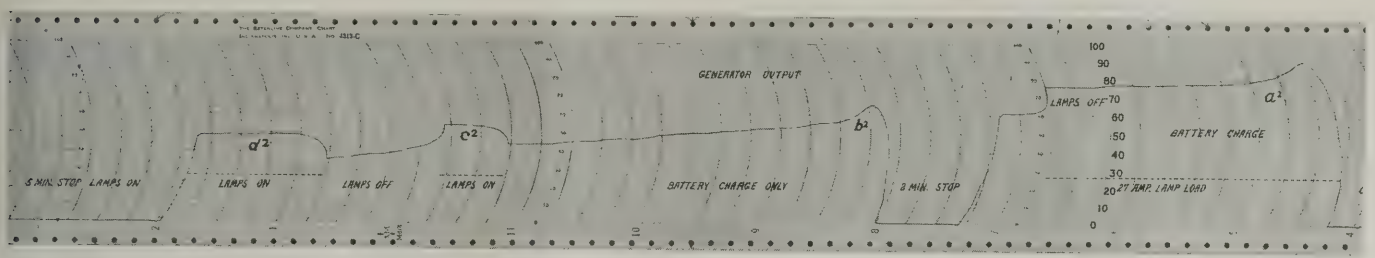
Fig. 15—Graphic Charts Showing Characteristics of

tery or dynamo be accidentally reversed, the equipment will automatically correct itself. For example, when the automatic switch closes, the polarity of the dynamo, if wrong, will be automatically reversed to correspond to that of the battery, without damage or blowing the fuses.

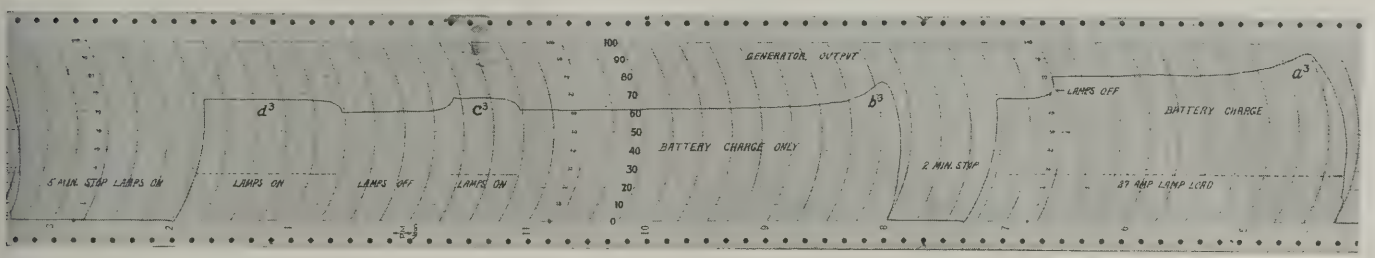
one since it will keep down the cost of armature repairs. The automatic switch closes when the voltage of the dynamo is slightly above that of the battery and opens when the current from the dynamo drops to zero. Then there is absolutely no flickering of the lights, when the



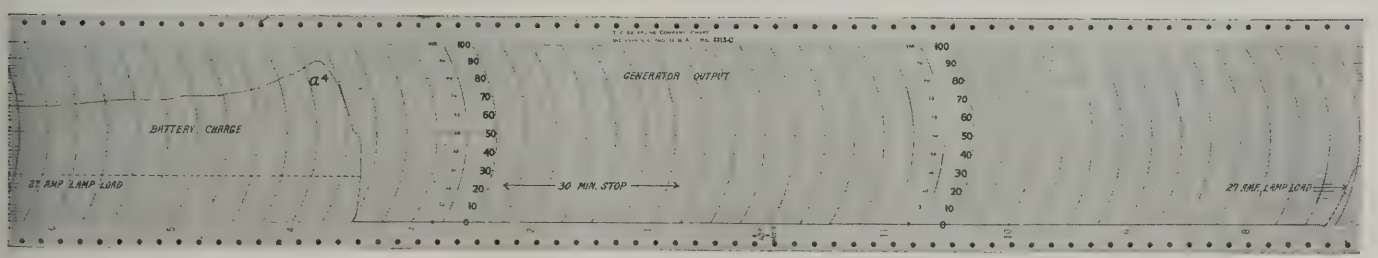
30 amp. Then after a two minutes' stop and discharge at 27 amps. (54 amp. min.) the output rises to 82 amps. (lamps 27 plus battery 55 amps.) almost output. The full battery condition then continues to the next five minute stop, after which it will be noted that the high output $a e^1$ is retained for a and two minute stops, respectively, where the former area is about half of the latter.



a^2 with a^1, b^2 with b^1, and so on out to the last minute.



for three hours before the start at a^3.



back in approximately two-thirds the time.

Constant Potential Charging in Car Lighting Service

The overcharge capacity of the dynamo is available for at least two hours for rapidly charging an empty battery without danger of overheating the machine since the constant voltage control automatically reduces the charging current as the battery fills up.

Excessive overload is prevented by the design of the pole cores which become saturated and reduce the voltage before a dangerous output is reached. This is true at all speeds. This last named characteristic is an important

switch opens and closes, and no burning of switch contacts.

No adjustments of any kind are required with the E. S. B. system and no means of adjustment are provided. The equipment automatically adapts itself to all the varying conditions of service, such as changes of schedule, different hours of lighting in winter and summer, express train and local train service, branch line service, change of lampload, etc.

Electrification May Interfere With Communication*

Tests in Switzerland Show Methods to Overcome Inductive Interference of High Voltage on the Telegraph, Telephone and Signal Circuits

By H. W. Schuler
Electrical Engineer, Swiss Federal Railways

THE overhead catenary contact circuit on the electrification of the Berne-Muensingen-Thun line of the Swiss Federal Railways, was so constructed as to permit extensive tests to determine the effects of the 15,000-volt propulsion on the low tension telegraph, telephone and signal circuits. The electrified section on which these tests were conducted is about 20 miles long and employs a 15,000-volt single phase, 15-cycle contact line.

Fig. 1—Catenary Construction in Tangent on the Berne-Thun Line

It was the purpose of these tests to determine conclusively whether the system of feeding the sections from both ends would neutralize the inductive interference on the telegraph circuits. It should be stated here that all such systems, as feeding from both ends, booster transformers and three wire systems, used to reduce this interference also reduce the reliability of the contact line and at the same time will not permit the use of grounded telegraph or telephone circuits.

Systems Used to Reduce Interference

The three-wire system reduces the voltage induced in the low tension telephone, telegraph and signal circuits along the railway, because the electromotive force induced by the current flowing in the contact line is compensated by the counter electromotive force induced by the current flowing in the transmission line and because the e.m.f. induced by the voltage of the contact line is compensated by the e.m.f. induced by the voltage of the transmission line, which is, at each moment opposite to that of the contact line.

The booster transformers reduce the voltage induced in the low tension lines because they bring the current flowing in the earth into the rails or in case of an insulated return line being installed, to this return line. Thus the e.m.f. induced by the trolley current is mostly compensated by the e.m.f. induced by the current that is forced to flow in the rails or in the insulated return respectively.

In a system where the sections are fed from both ends the e.m.f. induced in the communication lines paralleling an entire section by the current flowing from one end is compensated by the e.m.f. induced by the current flowing into the section from the other end.

Description of the Circuits

The energy for the electric traction on the lines Berne - Muensingen - Thun, Berne - Belp - Thun and Berne-Schwarzenburg is transmitted from the power station at Spiez to the substation at Thun by a feeder line that consists of two aluminum strands of 82 mm² each. The contact lines are fed through "main oil circuit breakers" mounted in the Thun substation.

Fig. 2—Showing the Air Sectionalizing at the Ends of Stations and Arrangement to Keep the Contact Wire Tension Constant

These breakers will open automatically at overload and at short-circuits.

The contact line of the double track line consists of a hard drawn copper trolley wire of a 107 mm² (No. 0000) cross section, and of an iron strand of 85 mm² cross section. The lines that go from the air sectionalizing at the station ends to the switching towers are of aluminum strand of 100 mm² cross section.

The transmission line consists of two aluminum strands of 100 mm² cross section strung on either side of the railway line. The return line, insulated for about 1,000 volts, consists of two copper wires of 28.5 mm² cross section each. At each station this return line can be connected to the secondary winding of a booster transformer.

*The electrified section of the St. Gotthard Line was described on page 221 of the June issue of the *Railway Electrical Engineer*.

The rails have a cross section of 58.5 cm². The joints of the inner rails are bridged by copper bonds that have a cross section of 50 mm².

In the substation the tension of + 15,000 volts is transformed to — 15,000 volts by the auto-transformers. One terminal is connected to the contact line, the other to the transmission line. The middle point of the winding is connected to the rails. The three-wire system thus formed is, of course, unevenly loaded as there is only a load on the contact line side.

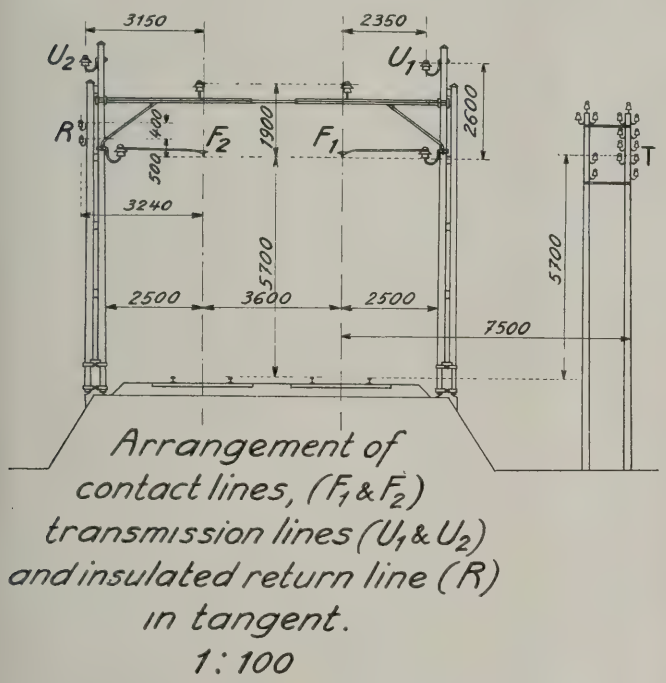


Fig. 3—Diagram Showing Relative Position of the Various Electrical Conductors

To balance the system auto-transformers are installed at Kiesen, Rubigen and Ostermundigen.

The sectionalizing of the line is made in such a manner that the contact line of each track between two stations and the contact lines of a station as a whole are connected to a busbar in each station, from which they can be disconnected by line circuit breakers. This sectionalizing system permits the cutting out of either of the two contact and transmission line wires between two stations or the contact lines of a station without interfering with the service on the rest of the line.

The Transformers

The auto-transformers have a continuous output of 2,000 kva. and may be overloaded with 50 per cent of the normal output for 10 minutes. The booster transformers have a continuous output of 7 kva. calculated on a primary current of 100 amperes. The maximum current which the transformers will be able to carry without reaching the saturation point of the iron is 600 amperes. The winding is made of aluminum, the magnetic circuit contains a 10 mm air-gap. The calculation of the boosters was based on an insulated return line consisting of two aluminum strands of a 100 mm² each. After the construction work was started it was decided to use these two strands as a transmission line. So a special return line consisting of two copper wires was strung.

Low Tension Telegraph, Telephone and Signal Lines

Previous to the electrification, the telegraph and telephone lines of the state and those of the railways were mounted on the right-of-way. During the electrification the state lines were transferred to about 800 meters from the railway line and built partly as a cable line (Berne to Rubigen) and partly as an aerial line (Rubigen to Thun). All circuits were insulated from the ground. The telephone and the telegraph loops were transposed at frequent intervals, the ground connections of the adjoining lines were transferred to distant points.

The low tension lines belonging to the railway, consisting of telephone, telegraph and signal wires, were left in place. The earth as a return path was eliminated, all loops were insulated from the ground and transposed at least every 500 meters. This loop was

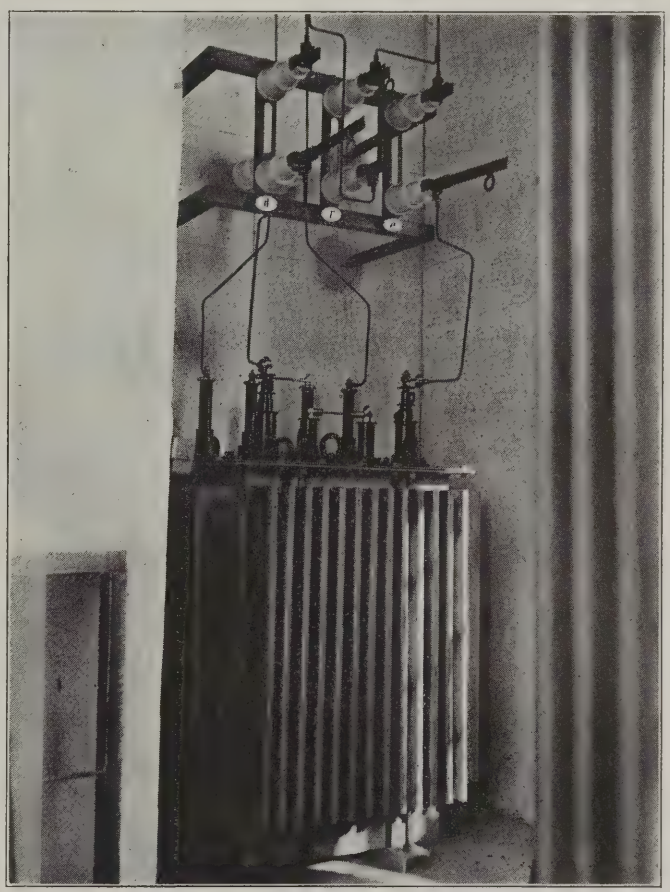


Fig. 4—Booster Transformer of 7 Kva. Continuous Output

grounded in Thun by means of an Ericsson coil which did not interfere with the use of the telephone. A milliammeter was inserted in the ground wire.

The position of the test wire relative to the track varies in some places, the track lies in a cut in other places on a fill, while the telegraph line in these places is placed on the slope and in stations or near highway-bridges the telegraph pole line leaves the right-of-way and follows the best suited route. The mean horizontal distance from the trolley wire of the track is 7.5 meters.

The Tests with the Three-Wire System

Beside the principle purpose already mentioned the tests with the three-wire system were also intended to find out the efficiency as to the transmission of energy as compared with the normal two-wire system; as to the interval in which auto-transformers should be placed and the importance of the line impedance and the transformer impedance for the repartition of the

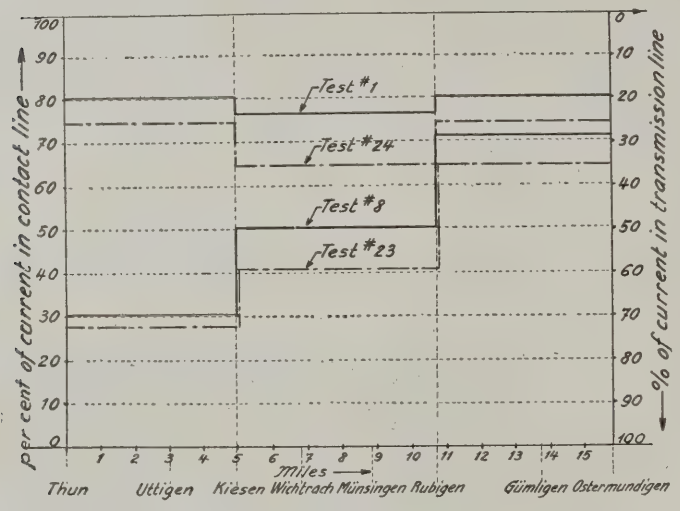


Fig. 5—Chart Showing Relative Percentage of Current in Contact Line and in Transmission Line During Certain Tests

total current to the contact and the transmission line. Tests were made.

(1) With four auto-transformers, contact line short-circuited at Ostermundigen, with and without boosters in series with the insulated return line.

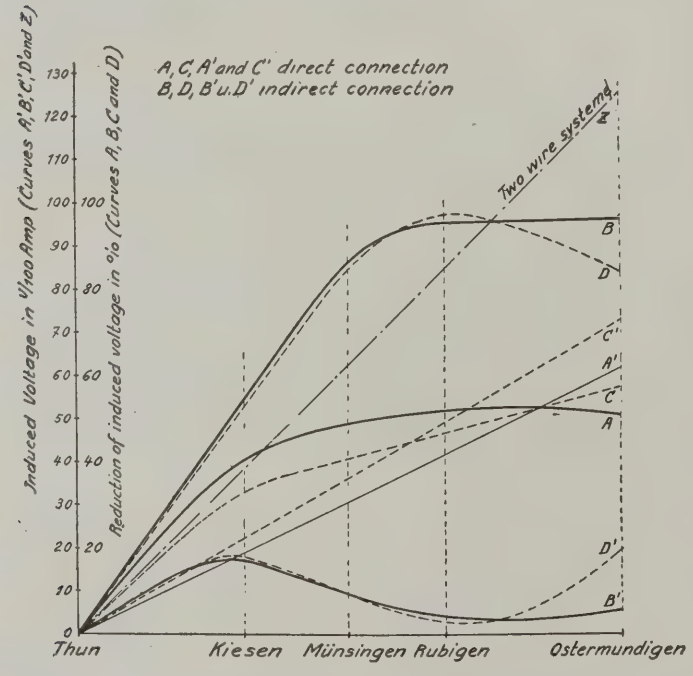


Fig. 6—Results of Tests Made With Contact Line Short Circuited Alternately at Different Points of the Line. Three-Wire Dynamic Induction.

(2) With four auto-transformers, contact line short-circuited alternatively at four different points of the line.

(3) With two auto-transformers, contact line short-circuited alternatively at four different points of the line.

In all these tests the contact line was connected

# of test	Stretch	Designation of low tension line	Average distance of low tension ligne from contact wire F_1 in meter horizontal	vertical	Designation of lines looded with 15000 Volt	Induced voltage Volt	Position of low tension line
102	Münsingen-Wichtrach	Telegraph-wire #633	8,00	+2,00	F_1	300	
103					F_2	140	
104					U_1	370	
105					U_2	70	
106					$F_1 + F_2$	380	
107					$U_1 + U_2$	528	
108					$F_1 + F_2 + U_1 + U_2$	10	
109					$F_1 + U_1$	590	
110					$F_2 + U_2$	183	

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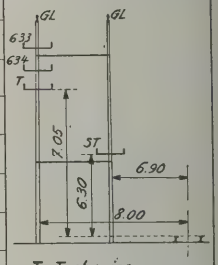


Fig. 7—Voltages Induced By the Tension of the Contact Line and of the Transmission Line Respectively. Static Induction.

to the rail at the "short-circuit point," the generator in the Spiez power-house being so excited that it generated a current of 100 amperes.

From the tests the following results were obtained:

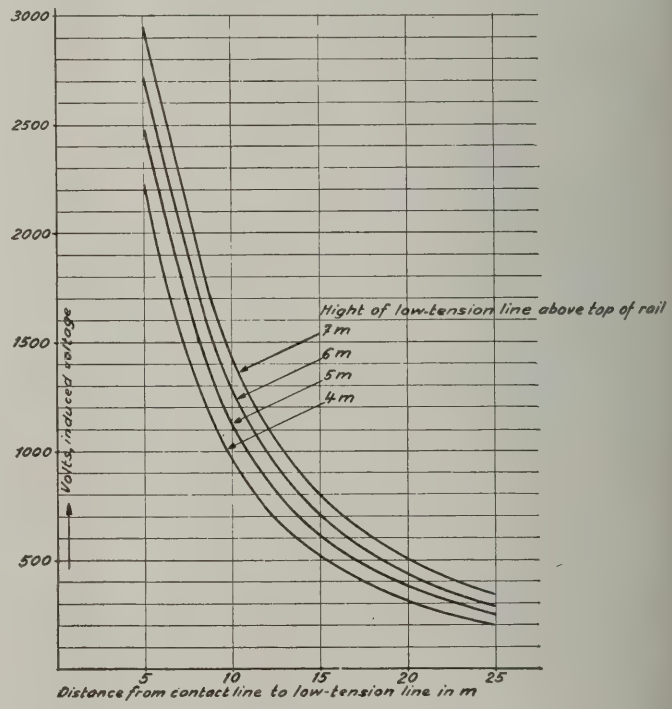

Volts induced voltage
Hight of low-tension line above top of rail
7 m
6 m
5 m
4 m
Distance from contact line to low-tension line in m

Fig. 8—Calculated Values of Static Induction in Low Tension Wire

(A) Inductive Interference from the Current (Dynamic Induction)

The three-wire system with the direct connection disturbs the service on the telegraph and telephone lines to such a great extent that a reliable service is not possible. The impedance of the auto-transformers is so much greater than that of the contact line that

only 20 per cent of the total energy is transmitted over the transmission line (see test No. 1 in Fig. 5). On account of this uneven distribution of the current the percentage of current flowing through earth and rail is high. So the insertion of the boosters greatly diminishes the voltages in the telegraph and telephone lines (see test No. 24 in Fig. 5).

The three wire system with the indirect connection shows a very good repartition of the current in contact and transmission line, which results in a very low induced voltage (see test No. 8 in Fig. 5). The insertion of the boosters can not better the situation, on the contrary it makes it worse (see test No. 23 in Fig. 5).

The principal results are put together in the following table:

System	Test No.	Volts/100 Amp.	Volts/100 Ampkm	Impedance Ohm/km
Direct connection without boosters...	1	62.0	2.44	0.124
Direct connection with boosters.....	24	23.8	0.94	0.374
Indirect connection without boosters..	8	5.2	0.20	0.190
Indirect connection with boosters....	23	69.0	2.72	0.333

From May, 1919, to December, 1920, the arrangement according to test 24 was in operation. The voltages induced in the telegraph lines were not disturbing the service. Since December, 1920, the arrangement according to test No. 8 has been in operation and even short-circuits do not disturb the service on the low-tension lines, but are audible as a loud crack. However, no low-tension apparatus has been damaged and no fuses blown.

The results of the tests made with 4 and 2 auto-transformers and with the contact line short-circuited alternatively at different points of the line are shown graphically in Fig. 6. Based on the voltage induced in the telegraph lines by the contact lines of a double track line without auto-transformers, boosters or anything of the kind, the percentages of the diminuation of the disturbances by using a three-wire system are shown in the curves A and B. Curves A^1 and B^1 show the induced voltages in volts per 100 amp. They can be directly compared with the curve A. The curves C, D, C^1 and D^1 give the respective results ob-

Table I — Tests without booster transformers — Length of test line 15,8 miles

		Fig. A	Fig. B	Fig. B	Fig. B	Fig. B	Fig. B	Fig. B	Fig. B	Fig. C	Fig. C	Fig. D
R=57mm²Cu, U_1=60mm²Cu, U_2=60mm²Cu; Disposition of wires looking from Berne to Thun		No isolated return line	R as isolated return line	U_1 as isolated return line	U_2 as isolated return line	U_1+U_2 as isolated return line	U_1+U_2+R as isolated return line	U_1+R as isolated return line	U_2+R as isolated return line	U_1+U_2 as isolated return line	U_1 as isolated return line	U_1 & U_2 alternatively as return line
										not grounded in Ostermundigen		
Induction in Volts/100 Amp.	contact lines F_1+F_2	118	113	100	104	92	85	93	95	963	—	14,2
	contact line F_1	128	120	107	113	—	—	—	—	—	31,2	—
	contact line F_2	98	94	89	90	—	—	—	—	—	—	—
Induction in Volts/100 Amp km	contact lines F_1+F_2	4,64	4,44	3,94	4,09	3,62	3,35	3,66	3,74	0,63	—	0,56
	contact line F_1	5,04	4,72	4,21	4,45	—	—	—	—	—	1,23	—
	contact line F_2	3,86	3,70	3,50	3,52	—	—	—	—	—	—	—
Impedance in Ohm/km	contact lines F_1+F_2	0,160	0,170	—	—	—	—	—	—	0,327	—	0,463
	contact line F_1	0,270	—	—	—	—	—	—	—	—	0,598	—
	contact line F_2	0,270	—	—	—	—	—	—	—	—	—	—
Current in the return line	contact lines F_1+F_2	—	15	15	14	27	32	23	22	100	—	100
	contact line F_1	—	13	17	13	—	—	—	—	—	100	—
	contact line F_2	—	13	15	16	—	—	—	—	—	—	—

Fig. 9—Tabulation of Results from Tests Without Booster Transformers

tained with two auto-transformers, one in Thun and one in Ostermundigen.

(B) Inductive Interference from the Voltage (Static Induction)

The voltages induced by the tension of the contact line and of the transmission line respectively were measured on different telegraph and telephone wires between Ostermundigen and Thun. Fig. 7 shows some of these measurements. The curves in Fig. 8 give the calculated voltages induced in a single low-tension wire, perfectly insulated, with different distances from the wire with the disturbing voltage. The great difference between the measured and the calculated voltage lies in the fact that only a part of the influence current goes to the test wire, while the rest goes to the paralleling wires, and that the insulation

of the test wire is not and cannot be perfect. The results given in Fig. 7 demonstrate that it is possible to compensate the voltage induced by the contact line tension. The more or less perfect compensation depends on the tension of the transmission line and on its relative position to the contact and the low-tension line, telegraph and telephone line.

(C) Repartition of the Current

The repartition of the current with and without boosters is shown in Fig. 5.

Some tests made with different values of the ratio:

$$\frac{\text{cross section of contact line}}{\text{cross section of transmission line}}$$

brought forth the fact, as already expected, that the influence of the cross section of these conductors is not the deciding factor but that the impedance of the auto transformers determines this repartition. An increase in cross section would not materially lower the impedance of the system as the inductive part of the resistance plays the more important part than the ohmic.

Impedance of the Three Wire System

As the impedance of a double track line without auto-transformers and transmission line is not more than 0.16 ohm per km it will be seen that the impedance of a three wire system—except the arrangement with the direct connection without boosters, which is financially and practically not desirable is always greater than that of a two-wire system.

Conclusions

With a three wire system the static and the dynamic induction in telegraph and telephone lines paralleling the railway can always be reduced to such an extent that the transferring of these lines out of the right-of-way of the railway is not necessary.

As a rule, it is possible to arrange the transmission line so that a compensated zone is formed in which all the communication circuits may be placed. The resulting reduced voltage in this zone being less than 100 volts. If such a position of the transmission line cannot be found, the tension of this line has to be chosen above or below the tension of the contact line, which means, of course, involve the design of auto transformers having a ratio that is somewhat different from 1:1.

A reduction of the dynamic induction to such an extent that the service on the telegraph lines is not disturbed is possible only with a three wire system having the contact line fed through the auto-transformers. For lines with a character similar to that of the Berne-Thun line intervals of 25 km between two auto-transformers are admissible. The division of the current between contact line and transmission line needs not to be strictly 1:1 as the influence of these currents on the communication lines vary with the logarithm of the distance.

A three wire system has a rather high line-impedance, it thus diminishes one of the advantages of

Table II — Tests with 4 booster transformers — Length of test line 15,8 miles

	U_1 as isolated return line				U_2 as isolated return line				U_1+U_2 as isolated return line				Fig.
	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	
	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	
Booster transformers in Gümligen, Münsingen, Wichtrach and Utigen disconnected. Isolated return line in these stations connected to rail. Booster transformers in serie without shunt. contact lines F_1+F_2	62	2,4	95	0,289	81	3,2	94	0,296	62,5	3,5	100	0,291	H
Booster transformers in Gümligen, Münsingen, Wichtrach and Utigen disconnected. Isolated return line in these stations not connected to rail. Booster transformers in serie without shunt. Contact lines F_1+F_2	54	2,1	84	0,358	61,5	2,4	83	0,362	33,3	1,3	95	0,282	J

Fig. 11—Tabulation of Results From Tests Made With Four Booster Transformers

Table II — Tests with 8 booster transformers — Length of test line 15,8 miles

	Fig. E				Fig. F				Fig. F				Fig. F				Fig. F				Fig. F				Fig. F				Fig. D			
	No isolated return line				R as isolated return line				U_1 as isolated return line				U_2 as isolated return line				U_1+U_2 as isolated return line				U_2+R as isolated return line				U_2+R as isolated return line				U_2&U_2 alternatively as return line			
	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance	Induced voltage		Current in the return line	Impedance
	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km	V/contact	V/coat/km	Amp.	Ohm/km
Boosters in serie without shunt, contact lines F_1+F_2	97,5	3,8	103	0,332	22	0,86	102	0,513	35	1,4	99	0,515	18,5	0,73	99	0,506	13,8	0,54	103	0,328	7,6	0,30	105	0,233	16,2	0,63	102	0,366	17,3	0,680	99	0,530
Boosters in serie without shunt, contact line F_1	110,0	4,3	104	0,467	—	—	—	—	26	1,0	102	0,746	28	1,1	98	—	9,0	0,35	103	0,462	—	—	—	—	—	—	—	—	22,8	0,895	96	0,64
Boosters in serie without shunt, contact line F_2	84	3,3	103	0,459	—	—	—	—	43	1,7	100	0,758	11,5	0,45	99		24	0,95	103	0,460	—	—	—	—	—	—	—	—	25,4	1,00	98	0,65
Boosters in serie with shunt, contact lines F_1+F_2	—	—	—	—	34,5	1,35	91	0,487	—	—	—	—	—	—	—	—	7,7	0,30	95	0,304	7,8	0,31	100	0,251	25	0,98	94	0,361	—	—	—	—
Boosters in serie with shunt, contact line F_1	—	—	—	—	47,0	1,85	89	0,605	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Boosters in serie with shunt, contact line F_2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Fig. 10—Results from Tests Made With Eight Booster Transformers

the single phase system which lies in the fact that the substations can be situated at great intervals. It further complicates the arrangement and the sectionalizing of the contact line. Therefore its application depends entirely on the solution of the financial problem, whether or not its installment will be less expensive than the transferring or the putting into cables the communication and signal circuits.

The Tests With the Booster Transformers

In most of these tests the two conductors of the transmission line were used as an insulated return line. This made it possible to determine the influence of the position of the return line relative to the contact line and the telegraph and telephone circuits. All tests were made with the ratio of the boosters being 1 :0.984; because the results of the tests showed the efficiency and the influence of the boosters. All these tests could only be made during the night from 11 to 4 o'clock. A part of the test was made with a shunt across the primary winding of the boosters. The ohmic resistance of this shunt was 8.8 ohms. In normal service these shunts proved to be too weak to

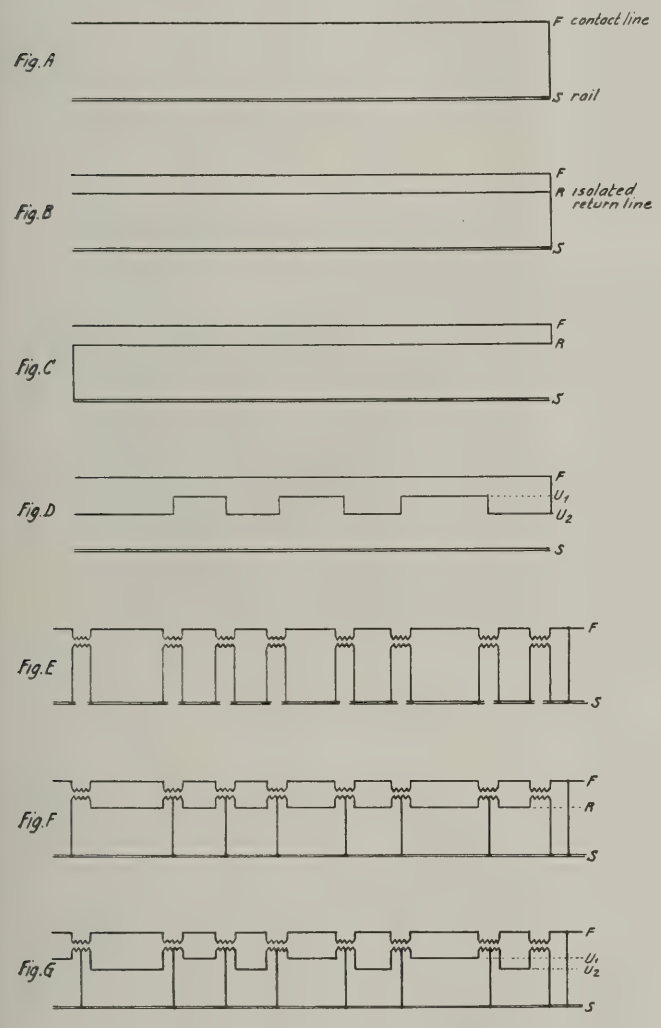


Fig. 12—Diagrams for the Tests With Boosters

withstand the short circuit current, they melted and had to be put out of service, so the greater part of the tests were made without these shunts.

The current in the rails was measured in only a few tests for on the greater part of the line the rails are fastened to iron ties with the joints resting on double ties. As the roadbed at the time of the tests consisted mostly of gravel mixed with sand and earth, much of the rail current went through the earth.

Dynamic Induction

The principal results of the tests are put together in the tables I, II and III (Figs. 9, 10 and 11), while the wiring diagrams are given in Fig. 12. The tests with the insulated return line parallel to the rail without boosters, show that the influence of such a return line alone is by far insufficient to reduce substantially the voltage induced in the wires by the current in the contact line.

The tests with 8 boosters having the secondary winding in series with the rails, showed that by this arrangement the resulting induced voltage is not small enough to permit a good service on the low tension lines. The reason for this fact is that the interval between two boosters is too great, the potential difference between track and ground can only reach a small value on account of the above mentioned roadbed condition, so the current is boosted only near the points where boosters are installed while in between it leaves the track as if there were no boosters at all. Tests made on the New Canaan Branch of the N. Y., N. H. & H. R. R., and on the Swedish State Railways showed that a distance of about a mile is the limit for the spacing of boosters that have their secondary winding in series with the rails.

A few tests have been made with 4 boosters, the results are interesting but not entirely reliable as the

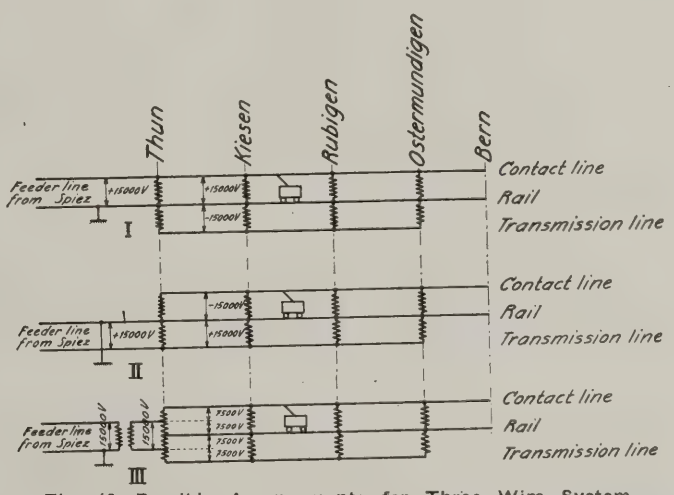


Fig. 13—Possible Arrangements for Three Wire System

boosters worked on sections of twice the normal length.

(B) Static Induction

With boosters only the dynamic induction can be reduced. When the low-tension lines are less than 30 meters away from the railway the installment of a "counter voltage wire" is necessary.

Boosters in connection with insulated return lines raise the impedance of a line very considerably. The increase may reach 100 per cent of the value, which holds good for a double track line without boosters.

With boosters spaced about 4 km apart in connection with an insulated return line, the voltage induced by the contact line current can be reduced to such an extent that an undisturbed, reliable service on the communication lines is possible.

The reduction of the induced voltage depends in a high degree on the relative position of contact line, communication lines and insulated return line. To compensate the static induction a counter voltage wire must be installed whenever the low-tension lines are

less than 30 meters away from the contact line.

The results obtained were not considered to be so perfect as to justify the installation of the tested system on the proposed St. Gotthard line. Although the results of the tests are favorable for the compensation of the inductive interference, they are not of a nature to promote the efficiency of the electric traction. The efficiency of the railway system would be reduced, the reliability of the system as a whole diminished and the maintenance more difficult.

It had already been decided before these tests had been made to sectionalize the St. Gotthard line in such a manner, that the sections between the substations could be fed from both ends, the line being continuous between two substations.

In a telegraph wire paralleling such a section fed from both ends on its entire length the voltage induced by the current flowing from one end to a certain point is compensated by the voltage induced by the current flowing from the other end to that point. Of course this compensation is not complete because, as a rule, the communication line has not at a constant distance from the contact wire and the voltage at the two feeding points is not just the same on account of the voltage drop in the transmission line.

Furthermore, on the St. Gotthard line the telegraph, telephone and signal lines could not be left as they were for the circuits had to be completed by insulated return wires. On the greater part of the line the poles stood on the right-of-way just where the poles for the support of the contact line were to be placed. Therefore, as the telegraph wires had to be removed, it was decided to place them into cables along the track thus diminishing the static induction. The means adopted for minimizing inductive interference have produced results that are entirely satisfactory.

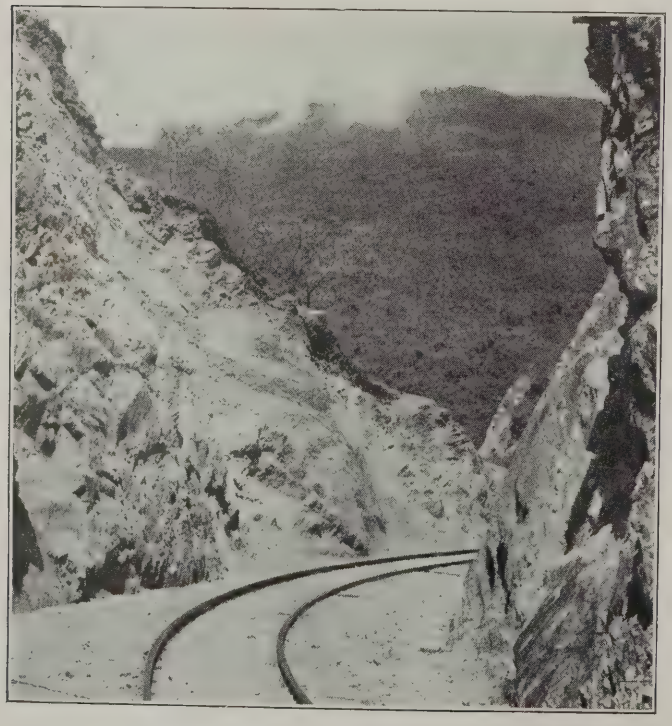


Photo by Keystone View Company, Meadville, Pa.

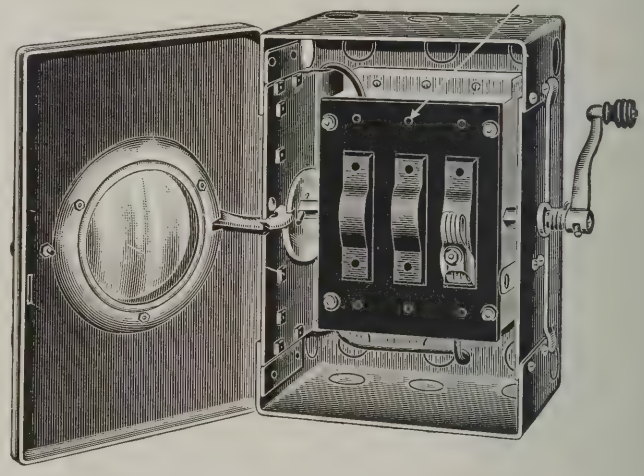
On the La Guaira & Caracas Railroad of Venezuela

A New Type Safety Switch

THE Super-Safety Electric Company of Chicago has recently placed on the market a new type of safety switch claimed to be safe in any position off or on, and which eliminates the live fuse terminal. The main part of the device consists of a molded rectangular block of insulating material having semi-circular compartments for each pole. Across the face of this block is mounted a square steel shaft on which are attached separate movable members on which are mounted the contact pieces and the fuses.

The make and break of this switch is caused by a semi-revolution of the shaft which carries the conducting and fusing members into or out of the channels in the block so that in the "on" position the fuses are carried in the channels and the face of the switch is an insulated surface. In the "off" position the contacts and fuses are lifted out of the connection with any live part; thus in either position security against personal contact with live members is obtained.

The plate cover is equipped with holes punched



Fuses Can Be Tested Through Test Openings Indicated by Arrow

directly over each line and load member in the base beneath, so as to facilitate the testing of the line and fuses, and it is claimed that this is the only switch having a rating in which this is possible. The case is provided with an interlocking device such that the switch cannot be operated either to the "on" or "off" position unless the door of the case is closed. For this reason it is not necessary to place a lock on the box although a slotted catch is provided in which a padlock may be used.

All the mechanism of this switch is mounted on a metal cradle which, with the door, can be removed from the bottom of the box so that conduits and wires can be installed without the interference of the switch mechanism. The switch proper can then be readily replaced and connected in. In locations such as roundhouses where gases would effect sheet metal, cast iron cases may be furnished. View is obtained of the operation of the switch through a glass in the door. All contacts and other members are readily removable from the front without the necessity of dismounting the entire device, and are as readily replaceable. The design of the switch is centered toward one principle object—complete security to all persons whether expert or inexpert.

Holding Device for Repairing Battery Plates

By R. F. Wilgus

In the February issue of the *Railway Electrical Engineer* there appeared a description of a Handy Device for Repairing Lead Battery Tanks. The device described herein is so designed as to fit on the same base used with this repair apparatus.

Many ways have been developed for repairing battery elements and the method here described seems to be the best that we have found. We cut off all plates from old battery elements, that is, if the plates look as if they could be used again. We save the bus bars and weld the old plates to them thus making a good element to use for renewals, obtaining in this way better service and much cheaper service than by using a new element.

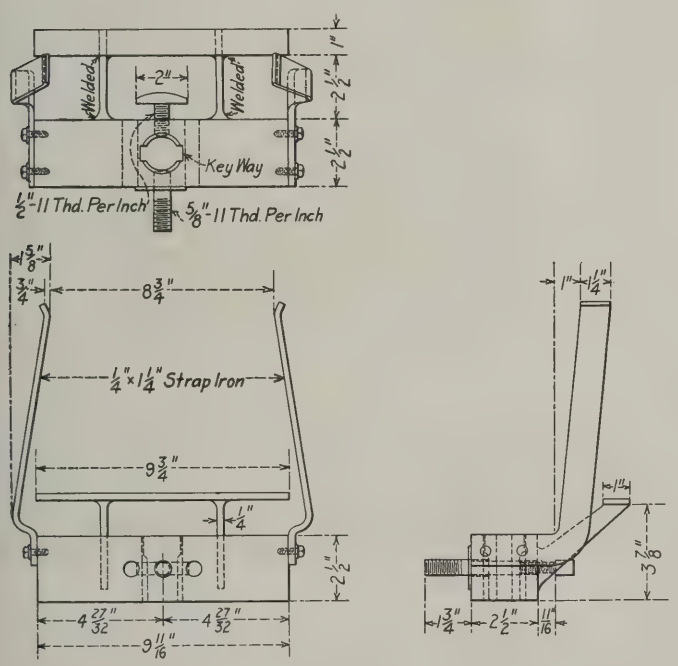


Fig. 1—Details of Holding Clamp

The construction details of the holding clamp are given in Fig. 1. They consist principally of a square bar of iron 9¾ in. long and 2½ in. square. This iron bar is drilled in the center of one side with a 1⅛ in. hole. On one of the other sides of this iron bar a 13/32 in. hole is tapped for ½ in. stud and a stud 3 in. long is run in and cut off, as shown in the upper sketch of Fig. 1. This stud is held in place by drilling a ⅛ in. hole through the iron into the stud and driving a ⅛ in. rod into the hole. On the other side directly opposite a 9/32 in. hole is tapped for ⅜ in. thumb screw which holds the element in place by clamping on the terminal post. Two pieces of strap iron ¼ in. thick and 1¼ in. wide, bent as shown in the illustration, serves to hold the plates in position. Two arms made of ¼ in. iron ¾ in. wide and 4½ in. long are welded to the bar. These are made to extend upward and backward and serve to support another strip of iron ¼ in. by 1 in. by 9¾ in. long which is welded to the suspending arms. When the plates are in position for repairing they are placed upside down as shown in Fig. 2. In this position the top of the plate rests on the extension brackets in the rear of the bar and the corner of the plate which connects to the battery strap is in the proper position for welding.

Old plates, which have been salvaged from old elements

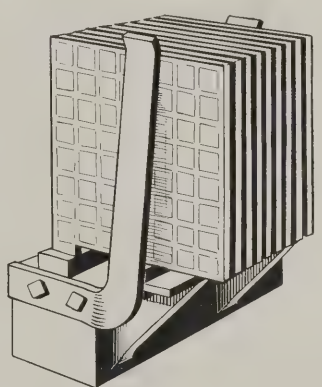


Fig. 2—Sketch Showing Position of Plates in Clamp

which are practically useless, are collected and placed in this holding device and welded to these brackets. Wooden separators are laid in between the plates so that they will come up square and be in the proper position for welding to the connecting straps. By attaching this holding clamp to the device described in the February issue, the workman is able to turn the plate in any desired position. If the work is done properly, gravity will cause the lead to flow together thus making a perfect weld. Be sure that all welding points are clean and hold the flame close to the lead thus preventing oxidation.

A certain traveler, on being asked, when purchasing a ticket, if he wished to travel first, second or third class, was told there was not much difference except in the fare, and decided to travel third class. When the train started he noticed that all classes of passengers seemed to be on exactly the same basis, and was curious to know where

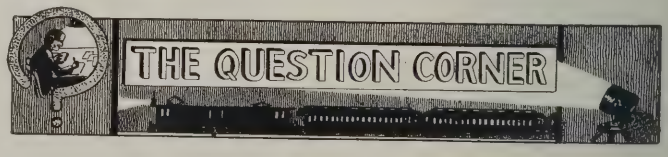
the distinction came in. After several hours of travel the train arrived at the foot of a very long hill, and stopped. The conductor came down the line and called:

"First-class passengers stay aboard; second-class passengers get out and walk; third-class passengers get out and push."—*Journal of Electricity.*

A Car Lighting Man's Dream*

William J. Miller ('course the name is fictitious),
Is a man who was never at all superstitious;
But a dream which he had is a direct intimation
Of his faith in the doctrine of predestination.
Now the said William Miller, please bear you in mind,
Is a Car Lighting Foreman, who, like all of his kind,
Has trials and troubles too many to state—
And, with this introduction, his dream I'll relate.
A spirit appeared at his bedside one night,
Decked out in a garment of pure spotless white,
And thus addressed Bill: "To me has been given
Command from the recording Angel in Heaven,
To ascertain why your name should appear
On the great Book of Life, as the reason's not clear,
The profanity record has been kept for ages,
And nothing like yours appears on its pages.
Therefore, 'tis decided, unless you can show
Just cause for defense, to send you below,
Where the fire is unquenched, and those who have never
Repented are roasted forever and ever."
On hearing the latter Bill tried hard to smile,
And invited the spirit to tarry a while.
"If I fail to make my defense in full measure,"
He said, "I'll be sentenced with the greatest of pleasure.
Please remain here tomorrow, accompany me
And report to headquarters whatever you see."
The spirit agreed, I am happy to say,
And took note of what happened the following day.
First, a conceited young clerk with expression Satanic
Brought a bundle of letters from the Master Mechanic,
And here are a few extracts I'll give an example,
Of a bunch that the spirit took away for a sample.
"Please note that the Superintendent complains,
We are having poor lights on our passenger trains."
"Please let me know what excuse you can make,
Why so many adjusting space bars 'Break.'"
"Lighting failures, last year for the month were but seven,
I regret for the same time this year there's eleven."
"You must take up the matter and ascertain why
We used so much oil in the month of July."
You are surely aware that a half-pint to use
Of machine oil per car is simply abuse.
I believe 'twould be wise (at least we can try it),
To give the men feathers with which to apply it.
"The President's special is leaving today
At 10:25, there must be no delay."
But, alas for the plans of mice and men;
The telephone rang at a quarter to ten,
And the station inspector announced with a drawl,
"The President's car has no lights at all."
A battery man appeared at the door,
"There's seven dead cells in the 864."
Then came a road inspector swelled up like a toad,
You'd think from his looks he would surely explode,
And asked loud in the name of the evil one:
"Why hain't the work on 490 been done?"
Bill Miller, he then made an angry retort,
While the spirit examined the inspection report
Of this road inspector, and this was the news—
"Renew the switch carbons and test the main fuse,
The belt is a-slipping, one battery cell leaks,
The rocker shaft bushing's so dry that it squeaks.
The lamps are flickering, clean carbons well,
The pulley end bearing runs hotter than—it should.
The tension rod bushings are worn on both sides,
The axle pulley sounds loose when she rides.
The solenoid sticks on the upward stroke,
Examine and see if the plunger ain't broke.
Flush the batteries and test them for grounds,
Shorten the belt and turn it around.
The machine's out of line an inch or more,
And fix the catch on the switch locker door.
I think from the way she's been throwing fire,
That somebody's set her output higher."
Before the good spirit got through taking notes
From the book containing the work reports,
From the Chief Engineer came a message which read,
"The Saint Louis Special's turbine is dead.
Have men at the station to meet the train;
Why you put this one on 41, please explain."
Then a batteryman said that when crossing a switch
They had upset a truckload of cells in the ditch.
The spirit departed, and on the same night
Returned with a crown, and in greatest delight
Presented to Bill's most astonished vision
A text of the Recording Angel's decision,
And a list of the great hero saints all revealed,
With William J. Miller's name leading the field.

*Reprinted by request from a former issue of the *Railway Electrical Engineer.*



Answers to Last Month's Questions

1. *I would like to have explained the difference between a reactance coil having an iron core and one without such core.*

2. *If magnetism can not be insulated or screened why is it that a brass or copper tube slipped over the iron core of an inductor coil cuts down the voltage at the secondary terminals.—B. R. E.*

* * *

1. The difference between a reactance coil having an iron core and one without such core is that the inductance effect is greatly intensified by inserting an iron core. The inductance of a coil without an iron core is small but a constant quantity, while the inductance of a coil with an iron core varies with the permeability of the iron. The inductance can also be adjusted by inserting more or less of the core into the soil.

2. The brass tube cuts down the voltage at the secondary terminals in the following manner. The brass tube is practically an independent secondary coil made up of a single turn. Its presence has a reactive influence on the primary circuit, which increases the further the tube is pushed into the coil, thereby reducing the induced voltage in the secondary coil. A. H. M.

* * *

1. Any reactance coil exerts a retarding effect upon the current in any alternative current circuit in which it is placed. The retarding is present whether there be an iron core in the coil or not, but the intensity of the retardation is greatly increased by the presence of an iron core.

2. In accordance with the laws of electromagnetic induction the brass or copper tube reacts upon the primary coil in such a way as to cut down the voltage at the secondary coil terminals. The action may be briefly described as follows: When the brass or copper tube is slipped over a part of the iron core it really forms a short circuited cylinder of very low resistance. The instant the primary circuit is closed the resulting magnetism induces in the tube a current, the direction of which is exactly opposite to that of the primary current which induced it. As a result the net amount of magnetism effective upon the secondary turns is the difference between that established by the current in the primary winding and that which results from the short circuited induced current in the tube. To what extent this action affects the secondary voltage depends upon how much of the secondary winding is within range of the magnetism resulting from the induced current in the short circuited tube.

* * *

In the June issue of the Railway Electrical Engineer I was interested in the question of changing the connections of a 220 volt, 2 phase, 4 wire, 60 cycle motor to

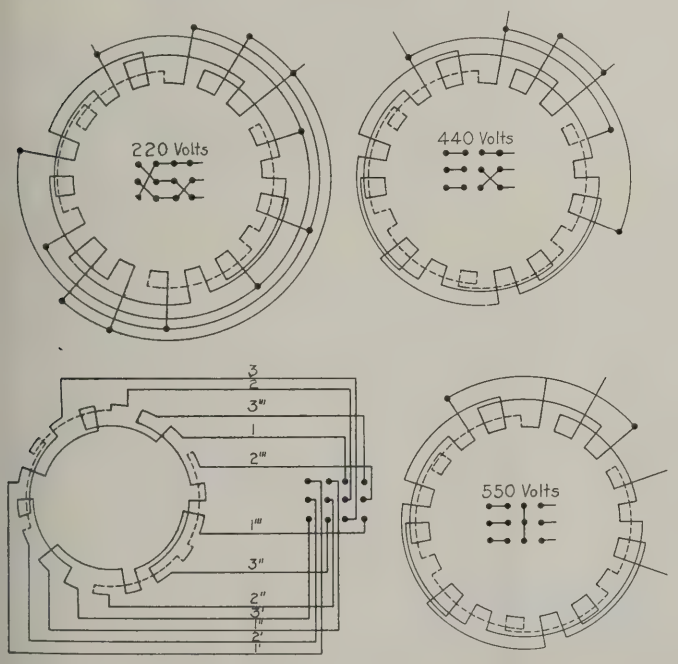


Fig. 1—Connections for 15-h.p. 60 Cycles Three-Phase Motor

440 volt operation. I enclose two blueprints showing how the leads are brought out to the terminal block on a three phase motor, and also on a two phase motor, for the different voltages, without having to take the motor apart. In quite a number of places where the voltages are different, it is necessary to have a spare motor on hand and by bringing the leads to the terminal block the changes can be made in a few minutes.

All of the sketches shown in Fig. 1 represent the same three phase motor, but connected differently. It will be seen that this motor may be used on 220 volt circuits, 440 volt circuits, or 550 volt circuits. In the lower left-hand corner of this figure will be seen a sketch which shows the leads from the various coils brought out to a terminal block on which the different connections may be made for

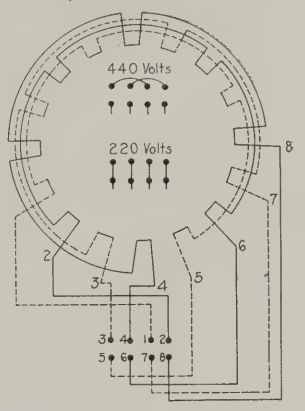


Fig. 2—Two-Phase Motor with Connections for Operating on Either 220 or 440 Volts

the various voltages. In the center of each of the other three diagrams are shown the various terminal connections to be used with the respective voltages. A little study of the 220 volt diagram will disclose the fact that it is delta connected with two parallel circuits, each circuit consisting of three groups of coils. For the 440 volt operation the winding is likewise delta connected, but with double the number of groups of coils in series. For the 550 volt operation the connections are changed from the delta arrangement to the star connection. All of these various connections may be readily made at the terminal block on the machine and to change from one voltage to another is comparatively a simple operation and requires but a few moments' time.

A similar arrangement is shown for a two phase motor in Fig. 2. This motor is wound to be operated either on 220 volts or 440 volts as desired. The connections at the terminals for both voltages are shown in the central part of the diagram. As was the case with the three phase motor on 220 volt circuits, this motor is also connected with two parallel circuits having four groups of coils in each circuit for 220 volt operation. For 440 volt operation, double the number of coils is connected in series between the terminals of the machine. A. W. W.

* * *

Questions for September

1. *Give formula for magnetizing a steel bar size 6 in. by 1½ in. by ½ in.; state length of wire, size, voltage and current, also the length of time required to magnify this bar.*

2. *Give test to determine if the bar is thoroughly magnified.*

3. *If a magnet loses its strength, can it be magnified to its normal strength?—A. H. M.*

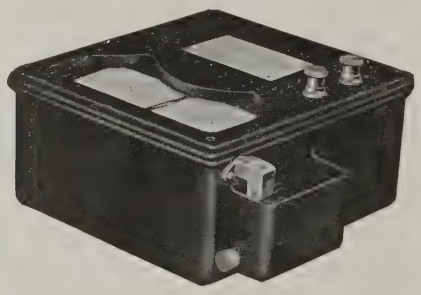
NEW DEVICES

Two New Electric Meters

Two new electric meters have been developed by the Esterline-Angus Company, Indianapolis, Ind., which are known respectively as the Concentration Meter and the Kilovolt Ampere Meter.

The purpose of the concentration meter, as the name implies, is to determine the percentage of a chemical or chemicals in a solution. This is accomplished by measuring the resistance of the solution. The meter has a large variety of uses and probably the most important in connection with railroad work would be the determination of the amount of chemical salts in boiler water.

For example, the amount of chemicals or sludge in a boiler increases as the boiler is used; little is carried over with the steam. This is particularly true where the water is bad and chemicals must be used to prevent the formation of scale. Blowing down a boiler does away with the sludge, but results in a loss of heat and water and should be limited to that amount necessary to prevent priming or corrosion. It is claimed that the concentration meter can be used to determine the time at which it is necessary to blow down a boiler.



Portable Indicating Concentration Meter With Container for Solution Attached

The instruments operate on alternating current and are made in both graphic and indicating types. Indicating instruments are used either by drawing a small quantity of the solution to be measured into a small cup attached to the side of the meter case, or by connecting the meter to electrodes which are continuously immersed in the solution. With the latter method, one instrument can be used with a number of electrodes, by using a dial switch to connect the meter to the different electrodes. Graphic instruments are used to make continuous records of the concentration or the resistance of the solution, and as a rule an instrument is provided for each electrode. The instruments are made in wall, switchboard and portable types.

The purpose of the kilovolt ampere meter is to provide a means for billing a customer in proportion to the cost of supplying him with power. The K. V. A. meters record maximum demand, take both power factor and unbalancing into account, and give a demand billing which is proportional to the investment cost of the service. The meters are made in portable, switchboard and wall types for all commercial voltages and frequencies, with chart speeds ranging from ¾ in. per hour to 6 in. per minute. The scale of the chart is uniformly divided throughout, making the record easy to interpret.

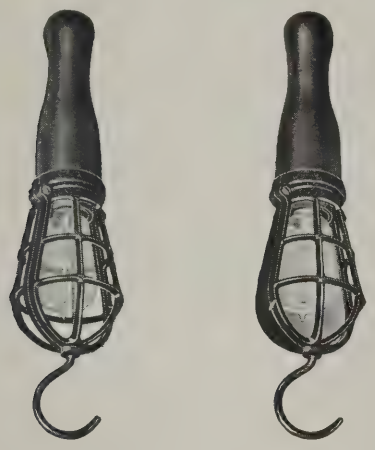
Portable Type Graphic K. V. A. Meter

Portable Hand Lamps

Two portable hand lamps designed to withstand severe service have recently been placed on the market by the Oliver Electric & Manufacturing Company of St. Louis. The lamp guards are strong, yet light, owing to the use of non-corrosive cast alloy and a maple handle of a weight sufficient to withstand rough usage and at the same time to balance correctly the weight of the guard.

The lamp guards are clamped in a groove in the handle which does away with screws. The receptacles furnished with these lamps are of molded insulation and have spring contact. They are mounted in the handles so that all the strain is taken on the handle. These receptacles are readily renewable.

Both types of lamps, one with a reflector, the other



Without Reflector With Reflector

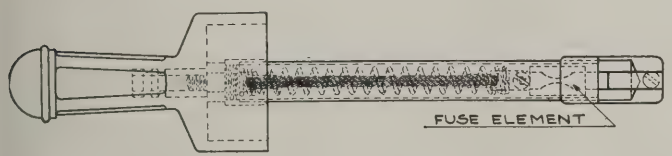
Two Portable Hand Lamps

without, are furnished with strain relief bushings in the handle so that the strain is taken on the reinforced cord and not on the receptacle wires. All guards are large enough to accommodate 50-watt lamps and equipped with substantial swivel hooks.

Ejector Cutout

Ejector cutouts for use on 2,200 to 6,600-volt service in which the arcing distance is increased automatically by a spring when the fuse blows, have been developed by Schweitzer & Conrad, Incorporated, Chicago, Ill.

The cutout consists principally of two parts, namely, a tubular shaped housing connected to the line, and a fuse tube containing the fuse and spring. The fuse tube, which is fitted with a handle, is placed in position by pushing it down into the top of the housing. A cylindrical shaped guard at the base of the handle fits down

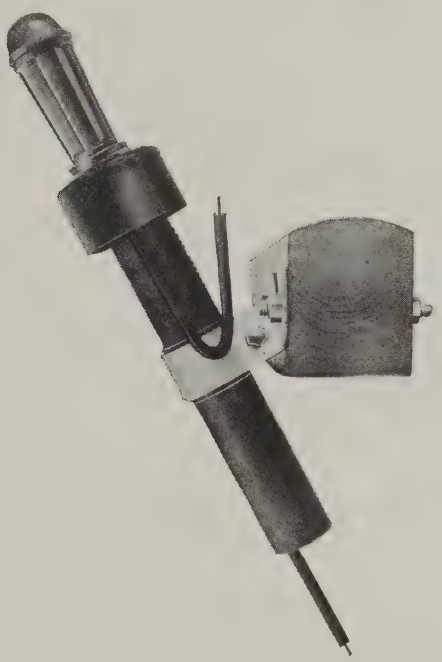


Fuse Tube and Handle Showing Location of Spring, Fuse Element and Cork

over the top of the housing, excluding water, snow and sleet. The housing and handle are made of molded insulation. The leads pass directly through openings in the main housing, and are secured to the internal contacts with no live parts exposed. The supporting clamp for mounting the cutout on the cross arm is made of galvanized steel and fits around the housing tube. A moulded recess in the housing fits the clamp and prevents the housing from working loose or sliding down through the clamp.

The fuse element consists of a strip with a fusible section, this fusible section being reinforced by a high resistance, high tensile strength fusible wire which is held in tension by a coil spring. The purpose of the wire is to relieve the fuse element proper from tensile strength. The fuse element is provided with slots for quick insertion under the terminal screws, and is enclosed in a cork which prevents it from corrosion and which acts as an arc barrier. The fuse tube is made of bakelite and is screwed to the operating handle. The spring is enclosed in the tube and is attached permanently to the handle. The fuse element is held in tension between the terminal end of the spring and the end of the fuse tube, thus making a rigid unit of these parts. The current passes from the base of the coil spring to the fuse element, through a flexible copper cable. The current carried by the spring is, therefore, very small.

The fusible link is normally held in tension by the



Ejector Cutout Complete Mounted on Cross Arm

spring and if the link is broken from any cause whatever, the spring contracts and introduces a long gap in the fuse tube. This quick-brake action of the spring is assisted by the barrier effect of the cork which encloses the fuse element. If the fuse operates on an overload just sufficient to melt the fuse link, a positive break is secured. In the case of short circuit, the cork is ejected by the explosive action of the arc, and it is maintained that besides acting as a barrier, the cork helps to interrupt the arc by sweeping it out of the fuse tube.

The cutout is mounted on the cross arm at such an angle that any flame or gases escaping from the open end at the bottom are directed away from the lineman on the pole. The cutouts are made in various capacities ranging from 10 to 100 amperes.

A number of combinations, consisting of disconnecting switches, horngaps, choke coils and fuses, for voltages from 7,500 to 37,000, are manufactured by this company. Fuse tubes for the higher voltages are fully enclosed and contain an arc extinguishing liquid having a high dielectric strength, which aids in opening the circuit.

General News Section

The Delta-Star Electric Company, Chicago, has established a district office at 310 Security building, Minneapolis, Minn., in charge of J. Sumpter.

Electric Railways and railroads in the United States are being studied by Kazucada Sakurai, equipment engineer of Tokyo, Japan, of the Municipal Bureau of Electricity, who is making a tour of the country.

Robert D. Black has been appointed manager of the Philadelphia branch office of The Black and Decker Manufacturing Company with headquarters at 318 North Broad Street. He succeeds W. C. Allen, who has been made special factory representative, with headquarters at the Cleveland branch office, 6225 Carnegie Avenue. Mr. Black was formerly assistant sales manager of the company.

The Association of Iron & Steel Electrical Engineers will hold its annual convention at the Hotel La Salle, Chicago, on September 19 to 23, inclusive. Various electrical devices such as A. C. automatic starters for slip ring motors, clapper switch controllers, dynamo cutouts, and many other devices of equal interest to the railway electrical engineers will be exhibited by various manufacturers at this convention.

The railways of Great Britain were returned to their owners on August 14, after having been under government control since 1914. The net income of the railways in 1920 is reported as $249,318,000, which is $7,290,000 more than in 1913. While the total receipts, including government compensation for 1920, were nearly two and one-third times the receipts for 1913, the total expenditures were nearly three and one-third times those of the pre-war period.

An unusual accident occurred recently on the Jamaica Bay trestle of the Long Island Railroad in which ten passengers were injured by flying glass. The wind pressure caused by two express trains going in opposite directions, passing each other on adjoining tracks, broke a number of windows in the third car of the westbound train. The glass did not penetrate that particular car, but many of the broken pieces were thrown through the open windows of the fourth car.

Wireless Telephone will be installed on important German express trains in the near future, according to a recent announcement. It is intended to have receiving instruments placed at various hotels and embassies so that travelers may arrange for hotel accommodations by radio telephone. Tests have been made under the supervision of engineers, military attaches and diplomatic representatives of the United States and Sweden, and these tests have clearly demonstrated that communication between moving trains and stationary points can be successfully accomplished.

Heating by Electricity on Swiss Railroads

For the last few months the passenger cars on the Berne-Thoune section of the Swiss Federal Railways have been supplied with steam for heating from electrical steam boilers. The heating unit of the boiler takes current directly from the overhead line without transformation and converts it into heat. This is the first electrical steam boiler installation working directly at 15,000 volts. The apparatus supplying the steam was built by Brown, Boveri & Company and is installed in an ordinary railroad baggage car especially arranged for this purpose. The maximum capacity of the boiler is 1,200 kw. A regulating device up to the minimum of 300 kw. has been provided. It is intended to introduce these heating cars on a larger scale on several lines of the Federal Railways.

Big Radio Station for China

Radio communication between Shanghai, China, and San Francisco—a distance of 5,360 nautical miles—is to be made possible by a 1,000-kw. arc station at Shanghai, construction of which is to start at once and which is to be completed within nineteen to twenty-four months. Contract for the construction of the plant, which will be similar to the station at Bordeaux, France, has been signed with the Federal Telegraph Company. A similar station is to be erected at San Francisco, and when both are completed they will, together with the Bordeaux station, constitute a chain by means of which messages can be transmitted entirely around the world. The separation of the three stations is almost exactly 120 deg. of longitude.

Although the power of the Shanghai unit will not be greater than that of the station at Bordeaux, several improvements, it is announced, will be incorporated in it. Among these are the "uni-wave" signaling system, which is expected to afford a distinct advantage for long-distance communication by improving the clarity of the signals.

Electric Locomotive for English Railway

Twenty electric locomotives belonging to the Metropolitan Railway are being rebuilt for the purpose of increasing their capacity. The general design of the locomotive is somewhat similar to that used for multiple unit cars, except that the locomotives are shorter, heavier, equipped with more powerful motors and the auxiliary apparatus such as the vacuum exhauster, air compressor, reservoirs, etc., are located in the cab instead of under it. The locomotives are equipped for multiple unit operation with the "all electric-automatic" type of control. There are two 4-wheel trucks, on each of which are mounted two 300 hp. series motors geared to the axle by single reduction gearing. Each motor is carried on its axle by suspension bearings, and a portion of the weight is transmitted by a nose on the motor casting which rests in a

yoke which slides vertically up and down in guides fixed to the truck crossbar. A slightly elastic support is obtained by rubber cushions. The principal dimensions of the locomotive are given in the table.

Length over all	39 ft. 6 in.
Width	8 ft.
Height from rail	12 ft. 4¼ in.
Distance between truck centers	20 ft. 3 in.
Length of rigid wheel base	9 ft. 3 in.
Total wheel base	29 ft. 6 in.
Diameter of running wheels	43½ in.
Gear ratio	26/54
Total horse power capacity	1,200

A number of special features will be incorporated in the rebuilt locomotives. An electrical interlocking device will make it impossible for the engineman to start the locomotive without first having the brake apparatus ready for immediate application. An automatic window wiper, operated from the inside, will enable the engineman always to have a clear vision in wet weather. The first and last cars of the train will be fitted with contact shoes and main positive and negative feeders carried through the train to the locomotive, thus making it possible for the locomotive to collect its current when the collector shoes on the locomotive are bridging gaps in the conductor rail.

Annual Meeting of U. S. L. Corporation

Confidence in the future of the U. S. L. Corporation was the keynote of the report submitted by President C. O. Miniger to the stockholders of the U. S. Light & Heat Corporation at their annual meeting held August 10th at the U. S. L. factory in Niagara Falls. The report, together with the financial statement, is being printed and will soon be distributed to all stockholders.

The following officers and directors were elected for the ensuing year: C. O. Miniger, president; D. H. Kelly, vice president; R. H. Van Nest, vice president and secretary; H. I. Shepherd, treasurer; A. F. Strayer, assistant treasurer; T. G. Swannie, assistant secretary. The board of directors consists of John N. Willys, chairman, New York; Egbert H. Gold, vice chairman, Chicago; Walter P. Chrysler, James E. Kepperley, H. I. Shepherd, New York; C. O. Miniger, Toledo; W. B. Stratton, New York; Geo. B. Shepard, Niagara Falls; James O. Moore, Buffalo; D. H. Kelly and R. H. Van Nest, Niagara Falls. The members of the executive committee are John N. Willys, chairman; Egbert H. Gold, vice chairman; James E. Kepperley, H. I. Shepherd and C. O. Miniger.

International Conference Recommends Wireless Telephony Policy

At the recent Paris conference of the international wireless delegates, some very interesting and important recommendations were adopted. Major-General George O. Squier, chief of the Signal Corps of the United States army, presented a definite program, most of which is said to have been adopted, although the conclusions of the conference will be kept secret until they are presented to the various governments by their respective delegates.

Of chief importance is the selectivity of wireless telephony between various nations and in order to further promote this condition the conference adopted a recommendation that certain waves be assigned to each country, with treaty provisions limiting each country to the use of instruments adapted to those wave lengths so that the result would be secret wireless. It was agreed to apportion these waves, probably designating each group by color, so that each country might have the exclusive use of certain colored waves.

In the opinion of the conference, wireless communication will never supersede the submarine cables, and the extension of cable facilities was advocated.

The report of the conference offers solutions for problems that were not solved at the Washington communication congress. It is expected that this report will be submitted to the Washington government in November.

Metropolitan Section of Welding Society Meeting

The Metropolitan Section of the American Welding Society will hold its first fall meeting in the Engineering Societies Bldg., 33 West Thirty-ninth Street, New York, on September 20. The subject of the evening, "Practical Applications of the Electric Arc Welding Process," will be presented by E. Wanamaker, electrical engineer, of the Chicago, Rock Island & Pacific Railroad. Mr. Wanamaker not only has devoted years to the study of arc welding during which time he has developed many practical features, but he is also a most interesting speaker. The paper will have to do with the three prime requisites of electric arc welding; 1st—skill necessary in applying the weld or designing parts to be welded; 2nd—requirements of equipment; 3rd—quality of material to be welded.

Mr. Wanamaker is one of the few who can handle this technical subject so that it will be interesting and in such a way that everyone can understand him.

A. E. R. A. Annual Convention

The fortieth annual convention of the American Electrical Railway Association will be held in Atlantic City, N. J., on October 3 to 6, inclusive. The tentative program of the Engineering Association of the A. E. R. A. is as follows:

MONDAY, OCTOBER 3

MORNING

9:30 A. M. to 12:30 P. M.

Registration and Distribution of Badges at booth at Boardwalk entrance to Pavilion in front of Haddon Hall, corner of Boardwalk and North Carolina Avenue.

MONDAY, OCTOBER 3

AFTERNOON

2:30 P. M. to 5:00 P. M.
(Meeting held in Solarium of Haddon Hall.)

Convention called to order.
Annual Address of the President.
Annual Report of the Executive Committee.
Annual Report of the Secretary and Treasurer.
Appointment of Convention Committees.
Resolutions.
Report of Committees:

Apprenticeship Systems—F. R. Phillips, Superintendent of Equipment, Pittsburgh Railways Company, Pittsburgh, Pa., Chairman.
Heavy Electric Traction—Sidney Withington, Electrical Engineer, New York, New Haven & Hartford Railroad Company, New Haven, Conn., Chairman.

TUESDAY, OCTOBER 4.

AFTERNOON

2:30 P. M. to 5:00 P. M.
(Meeting held in Solarium of Haddon Hall.)

Reports of Committees:

Power Generation—A. B. Stitzer, Chief Engineer, Republic Engineers, Inc., New York City, Chairman.
Power Distribution—Charles R. Harte, Construction Engineer, Connecticut Company, New Haven, Conn., Chairman.

NOTE.—The Joint Report of the Committee on Stores Accounting, representing the Store Accounting Committee of the Accountants' Association and the Committee on Purchases and Stores of the Engineering Association, will be held in Accountants' Room in Hotel Chalfonte at 2:30 P. M.

WEDNESDAY, OCTOBER 5

2:30 P. M. to 5:00 P. M.

(Meeting held in Solarium of Haddon Hall.)

Reports of Committees:
Way Matters—R. C. Cram, Engineer of Surface Roadway, Brooklyn, Rapid Transit Company, Brooklyn, N. Y., Chairman.
Buildings and Structures—D. E. Crouse, Chief Engineer, Rochester & Syracuse Railroad Company, Syracuse, N. Y., Chairman.
Paper—"Work of the Underwriters' Laboratories"—George B. Muldaur, General Agent, Underwriters' Laboratories, New York City.

THURSDAY, OCTOBER 6

AFTERNOON

2:30 P. M. to 5:00 P. M.

(Meeting held in Solarium of Haddon Hall)

Reports of Committees:
Equipment—Daniel Durie, General Superintendent, West Penn Railways Company, Connellsville, Pa., Chairman.
Unification of Car Design—H. H. Adams, Superintendent of Shops and Equipment, Chicago Surface Lines, Chicago, Ill., Chairman.
Standards—Martin Schreiber, Chief Engineer and Manager Southern Division, Public Service Railway Company, Camden, N. J., Chairman.
Report of Convention Committees.
Resolutions.
General Business.
Election of Officers.
Installation of Officers.
Adjournment.

Personals

F. H. Sauter, formerly associate editor of the Locomotive Dictionary, has accepted a position with Gibbs & Hill, consulting engineers, Pennsylvania Station, New York City. His work with this firm will have to do with the development of railway electrification. Mr. Sauter was born in Schenectady, February 1, 1877, and was educated in the public schools of Schenectady. In 1894, he entered the General Electric Company's factory and completed a mechanical engineering course under private instruction during the factory employment period. In January, 1900, he entered the General Electric Company's drafting department and in 1903, he worked with the Schenectady Railway Company as assistant master mechanic. In the fall of 1904, he accepted a position with the Peckham Manufacturing Company of Princeton, N. Y., as electric truck designer. In 1905, he entered the services of the American Locomotive Company, Schenectady, N. Y., and while with this company, he held positions as draftsman and designer of steam locomotives, electric trucks, and electric locomotives, and as electric locomotive and truck estimating engineer. In December, 1917, he entered the employ of the Simmons-Boardman Publishing Company as associate editor of the Locomotive Dictionary. He accepted a position with the Crown, Cork & Seal Company, Baltimore, in May, 1918, and in July of that year was made supervisor of Trade Machinery, and in April, 1920, assistant manager of the machine erecting department. The duties of this position included adjustment of machine complaints and personal visitation of the trade in the entire territory east of the Mississippi and some of the Western states. On June 1, 1921, he resigned to accept his present position.

F. H. Sauter

Walter R. Pflasterer, railway sales engineer of the National Carbon Company in the Chicago territory, has resigned, effective September 1, to enter business for himself. He has organized the Direct Sales Company and is general sales manager with headquarters at 431 South Dearborn street, Chicago. The Direct Sales Company will act as manufacturers' representative handling railroad accounts in the Chicago district. Mr. Pflasterer was educated in the public schools of Braddock, Pa., and his first work was for the Carnegie Steel Company in the rolling mills at the Homestead plant. Later he went to California for his health and after about a year started to work in the signal department of the Union Pacific at Omaha, being engaged in construction work under A. G. Shaver and J. C. Young. Later he was transferred to the signal engineer's office and had charge of handling all material for the large amount of construction work on the Union Pacific in 1906 and 1907. Early in 1907 he was appointed chief clerk to the signal engineer and about a year later he entered the signal department of the Southern Pacific in California. In 1908 Mr. Pflasterer entered the service of the Chicago, Rock Island & Pacific as chief clerk to the signal engineer, which position he held until August 15, 1913, when he resigned to enter the railroad sales department of the Yale & Towne Manufacturing Company, New York. Mr. Pflasterer remained with this company until December 15, 1914, when he resigned to go with the National Carbon Company of Cleveland in the railroad sales department as sales engineer, which position he is leaving to go into business for himself as noted above.

W. R. Pflasterer

Trade Publications

A transformer temperature indicator is described in Bulletin No. 46041, issued by the General Electrical Company, Schenectady, N. Y. The device is known as the type H-2 A-C temperature indicator and is used for determining the temperature of transformer windings.

The Mechanical Appliance Company, Milwaukee, Wis., has issued Bulletins Nos. 401, 402, 403, 404 and 405 covering the "Watson" direct-current motor, alternating-current motor, multi-speed motor, slip-ring and high-torque motor and ball-bearing motor respectively.

All Benjamin electrical products are listed and described in catalog No. 23, published by the Benjamin Electrical Manufacturing Company, New York. The catalog is a book with a stiff cover containing 252 pages and special attention has been given to the grouping of the products listed to add to the convenience of the user. A number of new devices are included in this catalog.

Railway Electrical Engineer

Volume 12 OCTOBER, 1921 No. 10

Personal Efficiency

Efficiency has been defined as the art of getting things done, but it means more than that, for not only must work be done, but it must be well done and at a reasonable cost. Otherwise, the term "efficient" can scarcely apply to its accomplishment.

Every undertaking, great or small, must be planned and guided from its inception to its completion, and the degree of skill manifested in the day by day progress is an exact measure of the personal efficiency of the one in charge.

Personal efficiency of different individuals differs greatly and there are few, if any, who have attained so high a standard that further improvement is impossible. It is not within human limitations for any one to know all there is to be known about any particular line of endeavor, even though he may have followed that line for years. New ideas and new methods are constantly being developed and the man who makes his mark as being personally efficient is he who is ever on the alert to adopt the improvements and make them a part of his regular practices. The fall and winter months offer exceptional opportunities in the meetings of the various technical societies and railroad clubs and it is hardly possible to attend such a meeting without carrying away at least one suggestion that will pay many times over the effort made to secure it.

Direction of Design

Standards for electric traction equipment is a question demanding an ever increasing amount of attention. More lively interest in this subject is shown in European countries than in the United States because there is a greater need of electrification in those countries, but the time is coming when the question will be equally vital in this country.

It is true that at present there are few things in a sufficiently advanced state of development to warrant standardization. It would, for example, probably be unwise to restrict the possible development of the three-phase system, but if an effort is made to carry standardization as far as practicable, it will aid materially in crystalizing the information at hand and will give the railroad operator a more definite conception of the possibilities and limitations of electric traction.

In an article in this issue George Gibbs, chief engineer of electric traction, Long Island, points out many of the factors which govern and limit standardization and offers a number of suggestions. The letter is written to the Electrification of Railways Advisory Committee in England, and speaks specifically of British railways, but the statements as set forth apply equally well to railroads in the United States. Extensive standardization is without question undesirable and probably impossible, but electric traction equipment is being and will be developed and direction of design is of fundamental importance.

The Lost Opportunity

Under normal conditions the present issue of the *Railway Electrical Engineer* would have carried the reports of the various committees of the Association of Railway Electrical Engineers. In the course of ordinary procedure these reports would have been presented before the association at the thirteenth annual convention which was scheduled to be held this month at Chicago. Both the presentation of the reports before the convention and their publication in the *Railway Electrical Engineer* would have reacted greatly to the benefit of the railroad electrical men, and it is most unfortunate that the decision was made to cancel the arrangements for the convention. It is difficult, if not impossible, to measure by any monetary scale the benefits derived by men attending conventions, or to trace how these benefits are extended to the roads. And yet there are few who will question the good that is accomplished by conventions.

It is the opinion of the *Railway Electrical Engineer* that a great mistake was made in the cancellation of this year's convention, especially since the usual June meeting was also called off. Progress in engineering achievements is not secured by hermitlike methods, but rather through the interchange of ideas by men working along the same lines. To what extent the ideas of one man may assist the plans and projects of another may be difficult to determine, but it is most reasonable to assume that the experience of the one may easily save both time and expense on the part of the second, who may be engaged in almost identical work. The saving may be intangible, but it is nevertheless real, and the *Railway Electrical Engineer* is thoroughly convinced that the supposed saving resulting from the cancellation of the convention is far less than the ultimate loss to the various roads will be.

Although the opportunity is lost for the present, the convention will eventually take place and when it does the committees' reports should reflect conditions up to the time the convention is held. Undoubtedly much work has already been done on the various reports in preparation for the meetings that were to be held this month, but

however good such reports may be, the committees should not think of being satisfied with the present efforts, but should continue to improve and augment their several reports so that when they are finally presented they will be full of live, up-to-the-minute useful information that will interest and stimulate the men and react to the economical benefit of the roads represented.

An American Committee on Electrification

The Association of Railway Electrical Engineers during the past two years has done a notable amount of original work on the subject of railroad electrification. Committees of other associations have also been working on this subject, but there has been little co-operation between the several associations and the result is that much of the work has been duplicated. Railroads have been called upon to answer questionnaires sent out by a number of associations, all asking for information on a single subject.

A clearing house to remedy this situation was suggested a year ago by the committee on heavy electric traction of the American Electric Railway Association. At the annual convention this year, the same A. R. E. A. committee made an effort to put its suggestion into effect by including in its report a statement of the activities of each of the other associations which had committees working on this subject. This is without question a step in the right direction, but in the same report the committee presents a considerable amount of data and information which is largely a duplication of what has been presented previously by the Association of Railway Electrical Engineers. The electric locomotive data table published in this year's report, except for some additions, is largely a duplication of a part of a table prepared last year by the A. R. E. E. committee. Data is also presented on multiple-unit equipment in this report and the same report states that the A. R. E. E. committee is now at work on this subject. The bulk of the report consists of a bibliography, based largely on another bibliography issued two years ago by the A. R. E. E. committee, enlarged, reclassified and brought up to date. This rearrangement is spoken of as co-operation, but it undoubtedly involves a duplication of effort, as a new group of men has rehandled and reprinted the bibliography.

An invitation will probably be sent out by the American Electric Railway Association to the American Railway Engineering Association, the American Railway Association, Mechanical Division, the American Institute of Electrical Engineers, the National Electric Light Association, the Association of Railway Electrical Engineers, and such other organizations as the executive committee of A. E. R. A. may deem expedient, asking each association to appoint two representatives to serve on an American committee on electrification. The invitation may not meet with hearty response in all cases as the steam railroads are those most vitally interested in the subject, and it would seem logical that their representation should be in proportion to the magnitudes of their interest. Furthermore, it may not be entirely feasible for one committee to handle all matters pertaining to electrification. The fact remains, however, that there is a need of co-operation and all of the associations named should confer on the subject, and either form an American committee on electrification, or a steering committee which could assign appropriate parts of the work to each of the interested associations. In this way, much unnecessary duplication and lost motion could be done away with and the effort of the several committees united and directed.

Welding for Railroads

The field for the application of metallic arc welding in connection with railroads is so extensive that it seems to be almost without limit. In a general way the savings that can be effected by the use of welding are apparently more or less familiar to railroad men within whose province welding operations logically fall, but there are relatively few roads that are embracing their opportunities in this direction to anything like the degree that it is possible and practicable. There is scarcely a railroad department that cannot use electric arc welding to advantage, provided the road has sufficient courage and initiative to organize a force of welders and supervisors under the direction of a competent welding engineer. Very great savings can be made—in fact, are being made, as is plainly evidenced by the ideas set forth in a paper presented at the recent meeting of the Metropolitan Section of the American Welding Society by E. Wanamaker, electrical engineer of the Chicago, Rock Island & Pacific Railway. The first part of Mr. Wanamaker's paper is published on page 376 of this issue of the *Railway Electrical Engineer*. What Mr. Wanamaker has done for the Rock Island lines can be, and should be very much more generally done on other roads.

New Books

Testing of Continuous Current Machines. By Charles F. Smith. 4 in. x 6 in. Bound in cloth. 102 pages, illustrated. Published by Sir Isaac Pittman and Sons, Ltd., 2 West 45th street, New York.

The book contains an outline in compact form of the main principles involved in the practice of testing electrical machines for commercial purposes. It has apparently been the aim of the author to simplify the description of the method as much as possible and to lay emphasis on the main purposes of the tests. The book is intended for young engineers and much detail, and many tests which have a limited application have been excluded.

The Code at a Glance. By Hubert S. Wynkoop. First edition, 3 in. by 7 in., paper cover. 96 pages, not illustrated. Published by National Association of Electrical Contractors and Dealers, 15 West Thirty-seventh street, New York.

Code requirements which should be constantly in the mind of the contractor, the wire man, the estimator, and the inspector are arranged in the book in alphabetical order so that the user of the book can readily look up all of the rules on a certain subject and thus do away with errors and omissions that are apt to creep into the work. For example, if information is wanted on grounding, under this subject will be found ground detectors, system grounds, equipment grounds, ground conductors, ground connections and other information pertaining to that topic, all in one place, arranged alphabetically. Mr. Wynkoop is in charge of electrical inspection in the city of New York and has prepared the book in an effort to minimize the thousands of Code violations that have come to his notice during the past 25 years that he has been engaged in electrical inspection.

Electrification Progress on Italian Railways

A Number of Hydro-Electric Plants Are Under Construction, as Fuel Is Expensive and Hard to Obtain

By Giovanni B. Santi
Engineer, Italian State Railways, Rome, Italy

SINCE fuel oil is not produced in Italy, the railway companies, particularly the state railways which operate most of the mileage, and all the lines where the traffic is heavy, have been engaged for some years in substituting electric traction for steam motive power. The electric power used for this purpose is secured from

Line from Lecco to Colico, Showing Wooden Poles Used in 1901 for Supporting the Contact Wires

a number of hydro-electric power plants, and at the present time this number is being increased.

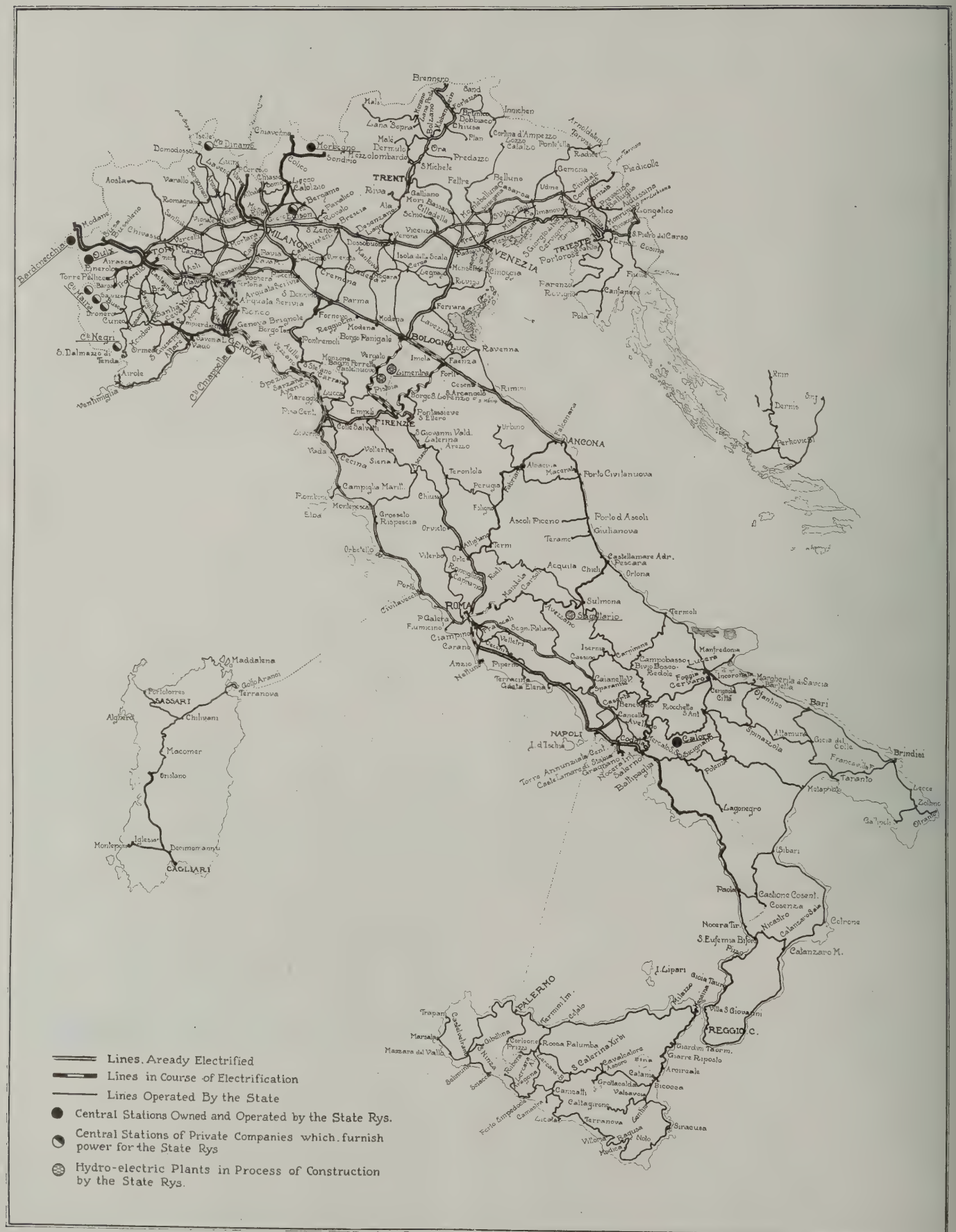
The Development of Electric Operation

The first trial of electric traction in Italy was made in 1901 and in that year the Milan-Varese line and the Valtelline line were electrified. The points between which electric operation was begun were La Lecco-Colico-Sondrio and Colico-Chiavenna. The electrification of the Milan-Varese line was carried out with a direct current, third-rail, using 650 volts. This line has a double track and is 36.7 miles long. It is still being worked with the same power plant which was installed in 1901 and enlarged in 1912 to cope with the increase of traffic. The direct current, third-rail system, gave some trouble during the first month of its operation, particularly on account of the overheating in the generators. These difficulties, however, were soon overcome to a large extent.

On the Valtelline line the 3-phase system was adopted with a low frequency of 15 cycles and 3,000 volts. The first installation was of an experimental nature and all the details were constructed in a very economical way, particularly as regards the contact line apparatus. Owing to the favorable results of the trial, some parts of the apparatus were strengthened later and at the present time, after a 20-year period of operation, the whole plant is running smoothly. The power is generated at 15 cycles in the power station at Morbegno on the river Adda, close to the electrified line. The copper contact wires are small,

The Monza-Lecco-Colico Line, Showing the New Contact Wires Supported by Tubular Poles of the Mannesman Type

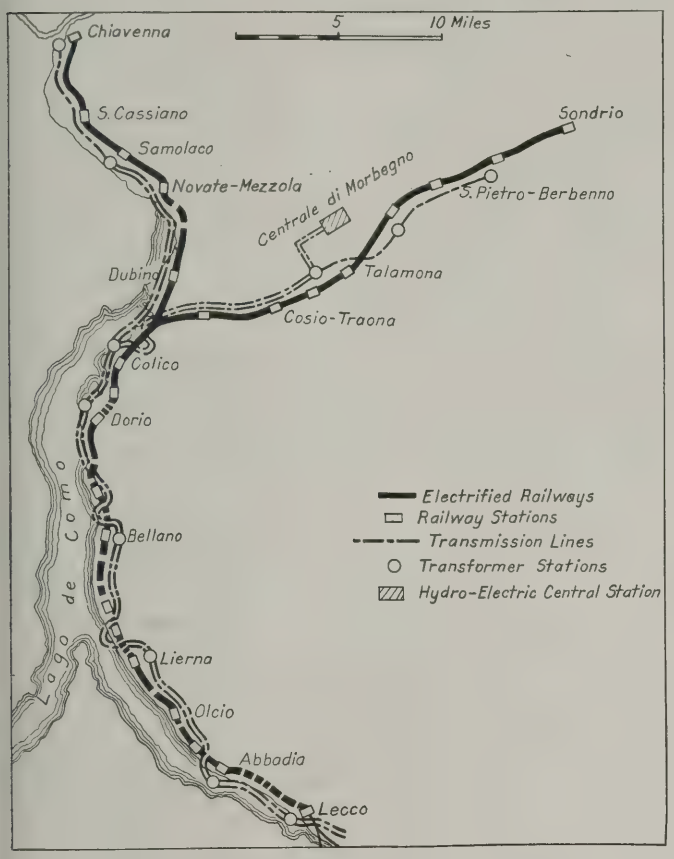
conductors having a cross-section of 50 sq. mm. being used for each overhead phase, the third phase being formed by the rails. The poles supporting the catenary were made of wood with transversal suspension as shown in one of the illustrations, except on small sections where two longitudinal types of suspension were tried which were proposed by the firms of Ganz and Westinghouse. The wooden poles were later removed and replaced by


Lines Aready Electrified
Lines in Course of Electrification
Lines Operated By the State
Central Stations Owned and Operated by the State Rys.
Central Stations of Private Companies which furnish power for the State Rys
Hydro-electric Plants in Process of Construction by the State Rys.

Map of Italian Railways, Outlining the Electrification Program

those of Mannesman tubular construction, also illustrated.

The transformer stations are of low power and are arranged in grades along the line with an average distance of about 6.2 miles between them. In 1901, the time at which the Morbegno plant was fitted up, it fulfilled the conditions of maximum economy on the total costs, consisting of interest and depreciation of the plant and cost of maintenance and operation. These conditions of maximum economy have now greatly changed, especially on account of the increase of wages and the introduction of the eight-hour day.



Lines Electrified in 1901 from Lecco to Chiavenna and Sondrio

The trial on the Valtelline line at once gave satisfactory results. It revealed great advantages in the three-phase traction system, particularly in regard to heavy traffic. This system was adopted, therefore, in the future electrification of the main lines of the State Railways, although alterations were made in all the details in order to render the equipment more technically perfect and more economical, particularly with regard to the maintenance and operating costs.

Recent Installations Applied to Lines With Greatest Grades and Traffic

The new installations were made on lines where the traffic was very heavy. Between the year 1910 and the year 1914 the two Giovi lines were electrified. These two lines, which connect the port of Genoa to the inland country across the Apennine mountains, encountering grades of 3.5 per cent, have the largest amount of traffic of all of the Italian roads. The Savona-Ceva line, connecting the port of Savona with the inland country, also crosses the Apennines at 2.5 per cent grade. The Bussoleno-Modane line crosses the Alps. This line has a tunnel 8.45 miles long at an altitude of 4,134 ft. above sea level. It is the chief line of communication between Italy and France.

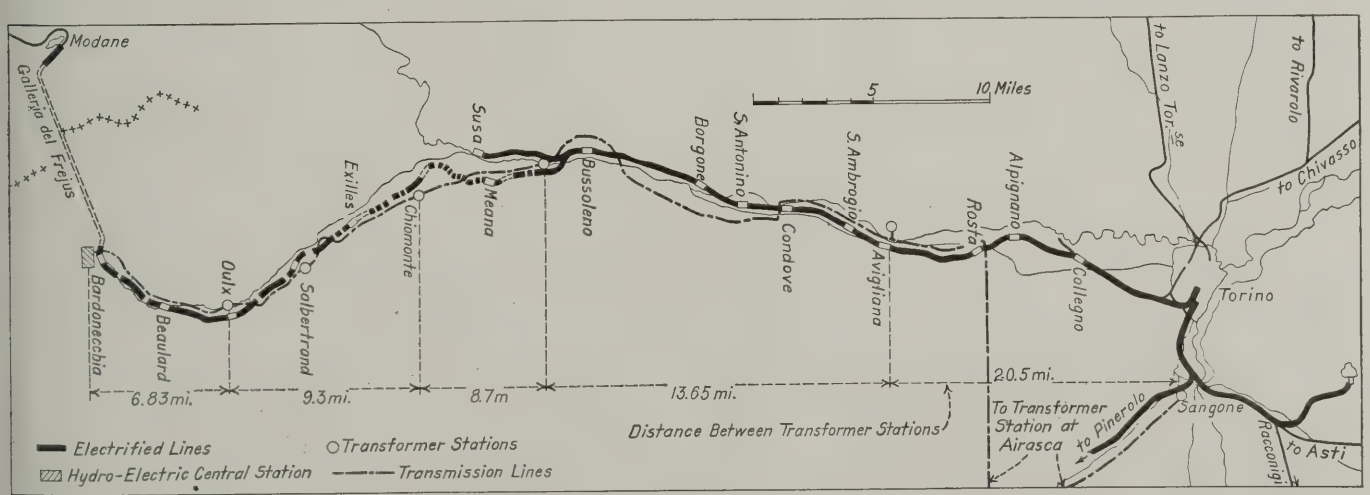
This group of electrified lines in the last few years has carried four times the amount of the average traffic of all the Italian railways. In the statistical year of 1917-1918, for instance, the average amount of traffic per mile of line on the whole of the State Railway system was about 2,060,000 ton-miles, while on the group of electrified lines mentioned above, the amount was about 8,800,000 ton-miles.

In 1916 the coast line between Savona and Genoa was electrified. This line connects the mountain lines referred to above, namely, from Savona to Ceva and the Giovi lines, and allows better use to be made of the apparatus and rolling stock on these lines.

Work in Progress

The electrification of the Pinerolo-Bricherasio-Torre Pellice and Bricherasio-Barge lines, 18.6 miles, will also be completed shortly. This is a continuation of the Torino-Pinerolo line, already electrified. The Torino-Chieri line, 13.7 miles, of which eight miles is double track, has been operating by electricity since March, 1921.

The power transmission lines and the electric transformer stations of the Torino-Pinerolo line were designed to supply either the Torino-Bussoleno line or the other

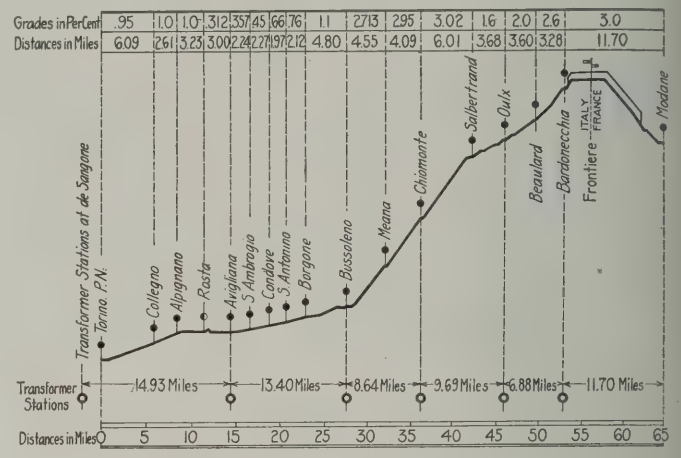


Electrified Line Put in Operation in 1919

lines which start from Torino, and which are at present in process of being electrified. The European war delayed the work of electrification, although it was never stopped completely, and immediately after the declaration of peace the electrification program was actively renewed. It was possible, therefore, to begin the electric service on the Torino-Bussoleno and Bussoleno-Susa line, 33 miles, of which 28 are double track, towards the end of 1919. In this way the Freyus electrified line (Bussoleno-Modane) and the Torino-Pinerolo were linked up awaiting the time when the whole of the electrified lines in Piedmont will be connected to those in Liguria, when the electrification of the Torino-Ronco line is completed, which should be at the end of 1921.

The electrification of the Voghera-Alessandria, Tortona-Nova and Tortona-Arquata lines, which will give access to the Giovi line, and the line from Milan to Chiasso and Switzerland will be completed in the beginning of 1922 at the latest. Nearly all of this work was agreed upon and commenced before the war. It is expected, therefore, that at the end of 1921 the electrified portion of the State Railways (that is the state-owned main lines), will be about 435 miles. As many of the lines have double track, the total length of the electrified section, including junction lines, freight yards, etc., will be about 808 miles. A summary of the more important features of the lines already electrified up to May, 1921, is given in the table.

on account of the steep grades and very heavy traffic. The total length of line operated by the State Railways is 8,700 miles and the annual consumption of coal is about 2,500,000 tons. The electrification of 2,800 miles, decided upon in the May, 1920, program, will permit of a saving of 1,300,000 tons of coal, or nearly half the total amount required for running the entire system. In its place,



Profile of Electrified Line Between Torino, Italy, and Madane, France

TABLE I—MILEAGE AND CHARACTERISTICS OF THE IMPORTANT ITALIAN ELECTRIFIED RAILWAY LINES AS OF MAY, 1921.

Lines Electrified	Length of Electric Lines: Outside Tunnels, Single Track	Outside Tunnels, Double Track	Inside Tunnels, Single Track	Inside Tunnels, Double Track	Total	Length of Electrified Track	Maximum Grades (per cent)	Minimum Radius of Curves	Weight of Rail (lb. per yd.)	System Used: Voltage	Current	Frequency
Lecco—Colico—Sondrio	40.	....	9.25	....	65.45	76.2	1.7	985 ft.	72 and 55	3,400	3-phase	15 to 16
Colico—Chiavenna	14.7	....	1.5	....			2.0	656 ft.				
Lecco—Monza	18.6	4.3	.3	....	23.2	39.7	1.2	1,640 ft.	72	3,400	3-phase	15 to 16
Milano—Varese—P. Ceresio	8.6	36.4	.25	....	45.25	90.7	2.0	985 ft.	72	650	D. C.	....
Torino—Bussoleno-Modane	10.3	12.8	4.5	37.3	64.9	110.	3.0	1,148 ft.	101	3,900	3-phase	16 to 17
Torino—Pinerolo	18.3	4.7	....	....	23.	37.9	1.3	1,969 ft.	72	3,700	3-phase	16 to 17
Savona—Ceva	22.6	....	6.	.05	28.65	43.4	2.5	1,312 ft.	101	3,700	3-phase	16 to 17
Ronco—Bivio Rivarolo (via Busalla)	....	10.9	....	2.9	16.9	49.6	3.5	1,312 ft.	101	3,700	3-phase	16 to 17
Campasso—Bivio Rivarolo	....	1.4	....	....								
Campasso—Bivio Succursale	....	1.7	....	....								
Campasso Suo Scali Maritt	...	....	....	....								
Genova B—S. Pierdarena	....	2.7	....	1.9	19.7	57.5	1.6	1,312 ft.	101	3,700	3-phase	16 to 17
S. Pierdarena—Ronco (via Mignanego)	....	7.2	....	7.9								
S. Pierdarena—Scali Maritt	....	....	....	....								
S. Pierdarena—Savona	19.6	....	5.2	....	24.8	31.8	0.7	886 ft.	92.5	3,700	3-phase	16 to 17
Torino—Chieri	13.4	....	....	....	13.4	19.4	1.0	1,640 ft.	64 to 72	3,700	3-phase	16 to 17
Bussoleno—Susa	4.7	....	....	....	4.7	5.2	1.0	1,640 ft.	55	3,700	3-phase	16 to 17
Total	170.8	82.1	27.0	50.05	329.95	561.4	....					

To these state-owned lines must be added about 124 miles of smaller electrified lines having standard gage track, which are operated by private companies. About 310 miles of narrow gage electrified lines are also operated by private companies.

Plans for the Future

The new work for extending electric traction in Italy, which was decided upon before the war by the State Railways in agreement with the government, provides for the electrification of about 2,800 miles of the State Railways. These lines are shown on the full page map. They have been chosen from those where the most coal is consumed 600,000,000 kw. hr. per annum will be consumed and this means that power stations will have to be provided with a capacity of 150,000 kw.

Most of the Electric Power Will Be Purchased

The power as a rule will be bought from private power distribution companies, but in order to speed up the work the State Railways have already commenced to build large hydro-electric installations, which will operate in parallel with the power stations of the private companies. These hydro-electric installations are those of Melezet and Rochemolles in the upper Piedmont section near Bardoneche; Suviana and Castrola on the river Reno and Limentre near Bologna, and Anversa on the river Sagittario near Sulmona in Central Italy. There are reser-

voirs in these hydraulic stations to provide a reserve of water for other stations in time of water shortage. The power which can be generated in these hydraulic plants is as follows:

Station at Melezet	26,000,000 kw. hr. per annum
Station at Rochemolles	40,000,000 kw. hr. per annum
Station at Sagittario	73,000,000 kw. hr. per annum
Station at Reno and Limentre	82,000,000 kw. hr. per annum
Total	221,000,000 kw. hr. per annum

It will be possible to generate in the stations at Reno and Limentre, when all the water is used, 127,000,000 kw. hr. more, making a total for all the stations now being built of 221,000,000 plus 127,000,000, or 348,000,000 kw. hr. These figures represent the limit of the annual power available from power stations. Of course, it will not be possible in practice to use this power in full. It must be taken into consideration, however, that the stations will be connected with other industrial power stations, and it will be possible, therefore, to transmit and use the power as it is required. Almost all of these stations are provided with reservoirs of water, and it will be possible to regulate the amount of power taken from individual power stations connected in parallel, so as to make the best use of the entire power system and get a maximum of power with a minimum waste of water. It is expected that the percentage of energy which is available will be about 80 per cent of the total.

Specifications for Catenary Construction

PRACTICALLY all of the overhead catenary contact systems now in use in this country are showing satisfactory results, according to the replies received from questionnaires sent out recently by the committee on power distribution of the American Electric Railway Association. It is, therefore, urged by this committee that comparative tests be made to determine the most economical type of constructions. The following is an abstract of the last report of the committee presented at the annual convention held in Atlantic City, N. J., during the week of October 3:

As a preliminary to the preparation of specifications for catenary construction a questionnaire was issued to 225 companies, asking information on 37 main points and replies were received from 59 companies, of which 15 had catenary to the extent of a total of 405 miles.

It had been hoped to secure information from other companies which did not reply and possibly in that case more definite facts would have been established.

A careful study of the replies, however, shows that with one exception none of the companies have had experience with types of catenary other than that they now use, and as all report favorable results, although the types employed differ materially, it is clear that there are needed comparative tests to determine the most economical construction.

A careful analysis of the information on this type of overhead issued by the various manufacturers showed wide variations in the figures on sags and tensions, due to the many variables in the problem. Moreover, there appears to be comparatively little information available on the details of the calculations. If this work is continued efforts should be made to secure some measure of agreement between the manufacturers, and that the complete analysis, with the agreed upon variable values should be made available to the members of the American Electric Railway Association, presumably as an appendix to the specification.

Certain general facts of interest shown by the questionnaire replies are:—

The oldest reporting line has been up for approximately twenty years; the majority, however, have been installed since 1912.

The tendency is for spans of 150 feet if on poles, or 300 feet if on bridges, using 7/16 steel messenger (2 use 500,000 c. m. copper cable on bridge work and 1 uses copper clad on poles) of various grades of strength, and 4/0 grooved contact wire, the latter at from 17 feet to 22 feet 9 inches above the top of rail. Hanger spacing varies, 15 feet being the choice of the majority, as is the flexible type of hanger.

Railway Electrification in England

Members of the Advisory Committee do not believe that any controversy will arise in connection with the proposals of the Ministry of Transport on the electrification of railways. The companies interested in the subject had a fairly strong representation on the committee, and the recommendations which were made in the interim report that future conversions of steam railways should be on the direct-current system, and that the standard of pressure at the sub-station bus-bars should be 1,500 volts, have now been confirmed. As might have been expected, however, the question of allowing the Brighton Railway Company to remain in a state of splendid isolation with its single-phase alternating-current system has aroused criticism, but the committee, having considered this subject in all its bearings, has come to the conclusion that for financial reasons it is not desirable to request the Brighton Company to revert to direct current working. The electrification of the main line to Brighton and other towns will, therefore, be on a single-phase system, and the work of extension is to be put in hand almost immediately. It is probable that the first of the railways serving the London district which have until now relied on steam working to equip suburban routes for electrical operation will be the Great Eastern Railway, whose plans are practically completed. It may be taken for granted that with the exception of the Brighton Company, the management of which is very desirous of extending electrical working to its main line trains, there will be no attempt to deal with main line electrification at the present time.—*The Engineer, Sept.* 16, 1921.

Electrification of the Most Northerly Railroad.—The most northerly railroad of the world—namely, that connecting the Bottnian Bay with the Atlantic Ocean—built for the transportation of iron ore, is now being electrified. The installation of this work is not an easy task, the average temperature at the town of Kiruna, the starting point of the road, being one degree above freezing and the lowest temperature 60 deg. Fahr. below zero. An order for eleven electric locomotives has been placed with the German Siemens-Schuckert company and the A. E. G. of Berlin. These locomotives will be the most powerful ever built in Europe. They will have to haul freight trains of 2,000 tons. The four motors of each these engines have a total rating of 2,132 kw.—*Electrical World.*

Applications of Electric Arc Welding*

Successful Welding Calls for Three Prime Requisites—Proper Equipment—Proper Materials and Necessary Skill

THE first fall meeting of the Metropolitan section of the American Welding Society was held at the Engineering Societies Building, New York, on September 20. The meeting was well attended and the program much appreciated. E. Wanamaker, electrical engineer of the Chicago, Rock Island & Pacific Railway, who has devoted much time and thought to the perfecting of the arc welding process and who has been largely responsible for the success which has been attained on the Rock Island lines, presented the following paper:

Fellow Welding Men:

I am going to begin this little discussion by asking what seems to me to be the most vital and insinuating question today—what is it that is retarding the application of the electric arc welding process? For I think that most all of us, at least those of us who are pioneers in this new art and therefore enthusiasts, know deep down in our own minds, that while we realize the progress has been fairly rapid, it has comparatively speaking, at least within the last two years, been very slow.

My personal opinion is that this delay is due to the dissemination of an extraordinarily large amount of mis-information, and the withholding or lack of dissemination of necessary vital information facts and factors. In other words we found after a careful survey made during the past twelve months, that there is a befuddling haze surrounding the entire electric arc welding process insofar as the average user of iron and steel products (including shop men, superintendents, engineers, managers, owners, etc.) are concerned. They have absolutely no correct knowledge as to the economic possibilities accruing to the users of this process, they practically all tell me, because they have been unable to secure any actual commercial data—they say that the manufacturers come to them and tell them a lot of things, but fail to produce any accurate specifications that will enable them to apply this process commercially in their individual businesses, so that it will be a money-maker for them. They tell me that to apply this process they must have the same information that they receive on other processes which they use in their everyday commercial business and they complain of the mystery and conflicting information they receive. They insist that what they require is definite and pointed information, both in general and in detail, so that they may form a decision, first as to whether or not they should use the process, and in case the decision be for its use, that they may be able to start immediately upon the right trail, or in the right direction, to secure economic results.

Naturally, a business man will ask three questions, and it is only natural also that these three questions refer to what we as pioneers know as the three prime requisites in electric arc welding:

First—What is the proper equipment to give us the most facile instrument or device—the one that will secure the best net economic results!

Second—What is the proper material for the job in hand—the material that will produce a weld that will meet the task or load imposed upon it by all the different factors that affect an electric arc weld, considering impact, alternate and repeated stresses, fatigue, etc.

Third—What is the skill required for our welding jobs, including skill in design of the job which is to be welded, or which might more economically be welded than performed by any other process? The skill required for supplying the accurate general and detail specifications for the jobs in hand, all of which skill is of an engineering nature. The supervisory skill is supervising the work and the operator's skill is performing the actual welding operation so that all of the welds made will be uniform and safe.

It has taken a vast amount of my time to make this survey but busy as I am, I feel amply repaid by the conclusions derived from the data obtained and these conclusions lead me to believe that this is no time, in the language of the late revered Theodore Roosevelt, for "pussy footing." "Pussy footing" has been one of the main factors in retarding the application and extension of the electric arc welding process.

I wonder how many of us have stopped to ponder and to realize that with all of our personal and individual ideas, we have failed to join hands to look these three prime requisites in the face, and as a body of welding men, agree upon some definite information to spread broadcast among the users of iron and steel—reliable specifications, complete in every detail from A to Z—facts and figures—so that any concern contemplating the use of this new art would not be misled into a haze or mistiness, which in a very short time will cause him to abandon the desire to make use of this new process.

I am trying to appear before you this evening, not as one working to secure or spread inspiration, but as an applicant, or rather as an insistant, that we endeavor now to stop our generalizing and, in the language of the street, "get down to brass tacks."

Sufficient demonstrations have now been made, that we need not fear so to do. As a matter of fact and record, if we may be pardoned for so saying, had we on the Rock Island Lines "pussy footed" and generalized, we would not be doing the important electric welding that we are today.

As you have noted from the title of this little talk "Practical Applications of the Electric Arc Welding Process," I was invited here to talk to you on practical applications, which must include "How are these

*The first part of a paper presented before the Metropolitan section of the American Welding Society by E. Wanamaker, electrical engineer of the Chicago, Rock Island and Pacific Railway. The second part of this paper will appear in the November issue of the *Railway Electrical Engineer*.

applications to be made?" It must be apparent to all that the first things to be considered are the three prime requisites. When plans and arrangements have been made so that the prospective user is enabled to comply with the demands of these three prime requisites, he is then in shape to begin the practical application of the electric arc welding process.

It lies within the possibilities of the American Welding Society to furnish much of the accurate information required, but they should not be expected to go thoroughly into the details and commercial aspects, such as are or would be necessary for any business, or business organization, using the electric welding process as a means of profit to themselves. Therefore, any business expecting to profit by the use of the electric arc welding process not only should, but must be willing to procure and make good use of the services of a fully qualified welding engineer.

Any user of the process, whether he use one equipment or whether he use several hundred, should have the entire operation or operations, carefully and properly planned from conception to conclusion.

Every large user of this process, should before beginning use of same, arrange to secure the services of a fully qualified consulting welding engineer, to assist him in the arrangements, plans and preliminary welding, including the development of a first class welding engineer to remain permanently in the business. Certainly, if it be possible, it would be well for the large user to engage or employ a permanent welding engineer at the outset, thus dispensing with the necessity for employing a consulting welding engineer.

Every small user should employ the services of a qualified consulting welding engineer, and just here it might be well to say, when we speak of welding engineers we mean a qualified welding engineer, as regards the electric arc welding process. Of course, in case it was a gas welding process that was being used, or was to be used, then the welding engineer should be fully qualified as a gas welding engineer.

The welding engineer should be fully competent to direct the purchase of the necessary proper equipment and materials for his clients, for proceeding with the practice of the art he should also draw up complete general and detail specifications for their guidance, and each welding job should be included.

It is true that there are but few fully qualified and fully competent welding engineers available today, but there is no doubt but that a plentiful supply of such welding engineers will be available as the work progresses and the demands for same increase.

I am strongly inclined to the belief that the success of the electric arc welding process on the Rock Island lines is primarily due to the foresight and vision of W. J. Tollerton, general mechanical superintendent, who some nine years ago came to the conclusion that there were great possibilities in the electric arc welding process, if same was properly developed and applied, and that great economics would accrue to the Rock Island lines through its use.

Mr. Tollerton realized that if the development and application was to be successful, it would be necessary to develop a welding engineer, with a competent staff, to handle all of the branches of the subject previously mentioned, including, as it were, the three prime requisites.

Although the welding itself is a metallurgical process, the heat and heat control is developed by the electric arc, and, in view of this fact, Mr. Tollerton decided that since I was a combination of mechanic and electrician (having come to the Rock Island as chief shop engineer, and afterward being made electrical engineer), that I was probably as well fitted for the work of welding engineer as any of our people, and the job was wished on me.

When I began the study of this process, I was not very enthusiastic, but after a year or two, when I began to see the possibilities, I became what may be termed "an electric arc welding enthusiast," and I am today glad, indeed, that Mr. Tollerton designated me to study and serve the Rock Island lines in the capacity of welding engineer.

Insofar as we are concerned, we have found that the three prime requisites, if successful electric arc welding is to be performed, are:

First—The proper equipment.

Second—The proper materials.

Third—Requisite skill.

The first of these necessitates an equipment that will give the actual heat application and heat control necessary to good autogenous welding, and one that will be the most facile possible to obtain. In other words, a skillful penman or artist can do much better work when supplied with the most workwise pen or brush—true, they might write or paint after a fashion with most any kind of an old pen or brush, even though far from suitable, yet the results would not be satisfactory.

It is possible today to purchase electric arc welding equipments that are satisfactory from a metallurgical standpoint, as well as from an electrical standpoint, and all qualified welding engineers are no doubt cognizant of the fact. However, it might be well to call attention to the following:

In considering a question of such importance as that of rating autogenous welds, the prevailing spirit should be not only to safeguard against the misuse of autogenous welds, but also to avoid unwarranted restrictions which may hamper the development and progress of the art. The growth of the welding art has already been retarded due to lag in perfecting the minor refinements of the various phases and not to any fundamental objections to the basic principles, which remain practically the same as from the conception of the art.

Many factors enter into the determination of the dependability of welded products. If proper consideration is given to these various factors, private and commercial interests should not be allowed to predominate. In the past, they have not infrequently been allowed to become involved in the conclusion, often to the detriment to at least some phases of an art or industry.

The volt-ampere characteristic and the stabilizing characteristic for arc welding circuits, if proper for ease of welding, must facilitate rapid variation of current and voltage, in response to variation of arc

resistance. The shape of a volt-ampere curve of a welding circuit may be proper and yet entirely unsatisfactory for welding, due to its slowness in response to the rapidly changing arc resistance.

The second primary factor—materials. There is a certain correlation between the parts to be welded and the material to be used in welding the parts, which it is necessary to consider for all classes and types of autogenous welding.

The thermal effect of localized heat on the structural arrangement of many kinds of metal is well known and is thought to be of sufficient importance to justify limitations of composition of materials to be welded. The cross section and thermal capacity will affect to a considerable extent structural changes caused from the localized heat.

The character of the metal from which the weld is constituted is a most important consideration in the quality of the weld. It is commonly admitted that the greatest deficiency in gas or arc fused metal is due to its low resistance to torsional, transverse and fatigue stresses. So far, improvements have been made in this direction only by affording better protection to the molten steel from atmospheric gases and by the use of alloy steels, the physical characteristics of which are not injured, but possibly improved by the heat cycle imposed by the welding conditions. Failure of welds due to strains of this character are also guarded against by reinforcement of the welded joint to a point greatly in excess of the elastic limit of the neighboring metal.

The third primary factor—skill—is sub-divided into engineering skill, supervisory skill and operator's skill—all of vital importance.

Any job that is to be welded (whatever its nature) should—if the job is a new one, be designed with the view of facilitating autogenous welds. If the job be a repair job, the application of the autogenous welding process becomes a more difficult one, since the original design did not contemplate the use of autogenous welding.

The supervisor of welding must be educated to become the go-between or medium of exchange between the designing engineer and the operator in the field or in the shop.

The operator in the field or shop is concerned primarily only with being able to properly fuse the metal into the weld when the proper specifications are furnished by the welding engineer and when properly supervised by the supervisors.

Fortunately, today it is possible to obtain welding equipments having the characteristics necessary for securing good autogenous welds—that is, such equipments are very facile. Also it is today possible to secure welding materials required for the various jobs in hand.

Unfortunately, there is a great dearth or scarcity of welding engineers, due to the infancy of the art and the natural inertia of the human being to take up that which is new and that which is not understood.

Without these engineers, who have the requisite skill necessary, mis-selections or mis-choices are apt to be made by the people in the business field when they are purchasing welding equipments and welding materials. Likewise, it is unfortunate that while we have many skilled operators, provided they are working under skilled supervisors and engineers, it is evident (and quite naturally so) that we have only a few skilled operators who can proceed to make uniformly good welds when left alone—that is, when furnished with improper equipment, improper materials, improper design and improper supervision.

From the foregoing, it may be easily deduced that I am taking the part of the autogenous welding operator, and in one way I am—he has certainly been one very much abused individual. I might well ask the question what we would expect of a boilermaker if some engineer did not properly design the job, purchase the proper material, design the proper tools, etc., in order that this boilermaker might shear some sheets and drive some rivets. For instance, I have found that it is possible to secure uniformly good welds, provided the design, engineering for the job and the welding, has been properly performed, and competent supervision provided.

Occasionally we have found a man who would not make a good welding operator and he was encouraged to leave the welding art alone and work at something for which he was suited. Just here it might be well to say that an autogenous welding operator (referring now to the gas and electric process) requires a welding wrist, which is somewhat similar to the telegrapher's wrist, or the wrist of an artist. There is a certain dexterity and movement required in securing good autogenous welds, in so far as the operator is concerned. A steady nerve and a quiet nerve is a highly important requisite, the same as with a skilled penman, and it is a well known fact that an artist, a penman or an expert telegrapher using the Morse key, cannot do good work if they are called upon to lift, heave and haul, and so strain their muscles, or upset or jar their nervous system. Hence, welding operators should not be called upon to do heavy manual labor. In other words, their welding wrist and nerves should be preserved. It may be that we are laughed at for making such a statement, but we have come to this conclusion after several years' handling of more than 350 operators working only on high grade welding where the best equipment, material and skill is required.

The ability of the welding operator has always been an unknown factor and probably always will be. A certain qualification of operators is obviously necessary. With proper design and prescribed methods of application and competent supervision, operators who have had the proper preliminary training and the usual amount of experience required to train the average student welder, will produce surprisingly uniform results.

The great differences in the efficiency of welds obtained by different operators have in some cases been due as much to the differences in design, methods of procedure, etc., as to the difference in the ability of the operators concerned. Sight should not be lost of the fact that most of the welding done in the past has been dependent upon the operator to work out all the facts enumerated above in addition to performing the weld, and in many cases improper designs and

methods of application have been employed, resulting in many undue failures.

The duty of the operator should only be to form the weld as physically sound as is humanly possible. The weld design, method of application and welding material best suited for the work at hand should be predetermined by test and research, according to the requirements of the welding products.

Equipment installation is an important factor. Having only two standard power voltages on the Rock Island, 440 volts 3-phase 60-cycle a. c., and 250 volts d. c., we have only two types of welding equipments, as far as power supply is concerned. Each power outlet is provided with a safety type fuse switch and receptacle, with plug and power connector to correspond. This form of connection is used even where stationary equipments are in service, since at any time it may seem desirable, the stationary equipment may be transferred to some other point, and a portable equipment used where the stationary was formerly employed.

Stationary equipments are used in shops where there is sufficient work always immediately adjacent to the equipments to keep them busy. We have found that a welding unit or equipment with a capacity of 200 amperes for continuous welding (manual operation), such as will permit the occasional use of approximately 225 amperes for intermittent work, and in emergencies, 250 amperes for a short time, is best suited to our use for all ordinary work.

We also use a very few similar equipments, except that the corresponding ratings are 300 amperes—approximately, 350 and 400. These machines are necessary where speed is an important factor when welding very heavy sections with large coated electrodes, the coated electrode making this possible.

These equipments are all purchased according to Rock Island specification, which in brief is as follows:

> 200 ampere capacity for continuous welding duty (manual operation), 65 volt max. open circuit voltage, portable electric metallic arc welding equipment, complete with control panel and motor starter. Welder set to be equipped with radial ball bearings. Truck to be equipped with ball or roller bearings. Cleat for 150 ft. of No. 2 cable, sheet metal cover with side and end curtains, to make entirely weatherproof. To operate on 3-phase, 60-cycle, 440 volt, a. c. circuit.
>
> Motor to be constructed so as to be easily reconnected for 220 volts. In case the power circuit is d. c., the motor should be a 250 volt d. c. motor.
>
> The welder shall be provided with suitable means for conveniently reversing polarity of welding circuit. The arc welder shall possess proper characteristics for good welding in all positions for arc current values from 50 to 200 amperes, as demonstrated by experienced operators, without causing undue fatigue on the part of the operator.
>
> Suitable means shall be provided for adjustment of current from 50 to 200 amperes, in steps of not more than 7½ amperes.
>
> 300 ampere capacity, portable electric metallic arc welding equipment, for continuous welding duty (manual operation) 65 volt max. open circuit voltage, complete with control panel and motor starter.
>
> Welder set to be equipped with radial ball bearings. Truck to be equipped with ball or roller bearings, cleat for 150 ft. of No. 0 cable, sheet metal cover with side and end curtains to make entirely weatherproof. To operate on 3 phase, 60 cycle, 440 volt, a. c. circuit.
>
> Motor to be constructed so as to be easily reconnected for 220 volts. In case the power circuit is d. c. the motor should be a 250 volt d. c. motor.
>
> The welders shall be provided with suitable means for conveniently reversing polarity of welding circuit. The arc welder shall possess proper characteristics for good welding in all positions for arc current values from 50 to 300 amperes. As demonstrated by experienced operators, without causing undue fatigue on the part of the operator.
>
> Suitable means shall be provided for adjustment of current from 50 to 300 amperes, in steps of not more than 7½ amperes.

We now have practically every shop, terminal, car repair yard and roundhouse of any importance, equipped with electric arc welding equipments, and expect next year to equip even the turn-around points. We find, however, that we are having to increase the facilities at all points—in fact, there seems to be no end to the growth and development in the application of the arc process to motive power, rolling stock, tracks and structures.

Due to the two standard voltages and our method of installation, we are able to use practically our entire equipment as a "flying squadron"—when the work or demand decreases at one point and increases at another, we are able to transfer the equipment, simply by loading into a box car or, if necessary, a baggage car, and shoot same to the point needed, where it is immediately available for service upon receipt.

The application of this process to car work is growing very rapidly just at present, and we will in all probability require a total of 150 equipments during the coming year. At the present time many of our equipments are double crewed and a few of them triple crewed.

Some track work has been performed with the portable shop equipments wherever power circuits were available.

We are now developing district electric welding cars for track and structural welding. For instance, a good box car will be converted in one end for living quarters for the welding crew, consisting of at least two men for a single unit car and three men for a double unit car. The other end of this car has large end doors. Portable run ways are carried with the car and used for loading and unloading the electric welding unit or units, in case two are carried.

These units are weatherproof and are built to the same specifications as the generators for our standard

welders, and are driven by high grade gas engines having smooth power impulse. The generator and engine are assembled on skids, which in turn are placed on well built push cars which may be moved about over the tracks from place to place by hand, or in case they are out on the line, can be trailed behind a section motor car. Each car is also equipped with a gas cutting torch and portable motor driven electric grinders and drills.

Before this car is sent to a large yard for reclaiming track work, the track foreman in charge at that point is instructed to have all his foundation work, frog bolts, etc., put into first class condition by local force, so that the welding crew will have nothing to do but the welding. The work is handled in a similar manner when out on the line. This gives by far the greatest economy, and insures the actual welding work being performed by experts, who are not required to do any other kind of work for reasons mentioned heretofore in this paper.

All of this welding, whether on carbon steel or manganese steel, is done with the coated high manganese electrode. Just here it might be well to state that in speaking of the electric arc welding process, as applied to our railroad, we automatically refer to the metallic arc welding process, as we do practically no carbon or graphite electrode welding at the present time, our endeavors having been confined to the development of metallic arc welding in view of its greater simplicity and we feel, generally speaking, better results.

We are glad indeed that we were so fortunte as to base our primary decision on the system method of equipment organization, as it has no doubt eliminated some very serious handicaps that might have otherwise occurred. At the same time we endeavored to build up a system organization, as regards the engineering, supervision and operation of this equipment, to the end that the greatest possible benefits might be obtained.

The fact that the Rock Island lines have a most excellent laboratory and test department, in charge of T. D. Sedwick, has been very much to our advantage, since the laboratory is especially well equipped for metallurgical work, and Mr. Sedwick and his staff are intensely interested in the development of the art, so it might be said that we had a foundation on which to start our operations.

A $50,000 investment was made in the initial start for equipment, and one of my assistants, H. R. Pennington, who seemed to have a natural talent and acquired intense desire to become proficient in this new art, was appointed "Supervisor of Welding and Electrical Equipment." As the work has increased, he has in turn been given two assistants, both of whom were boilermaker craftsmen, and who during the development of the art, became very proficient in all forms of autogenous welding and its application to all branches of railroad work.

We carefully taught our electricians how to install and maintain all of the electric arc welding equipment —at the same time we endeavored to teach all the operators the necessary detail and to supervise their work, and endeavored to impart as much information as possible to the heads of our motive power, rolling stock, and maintenance of way departments, including district officers, division engineers, shop superintendents, master mechanics, general foremen, foremen, etc., since it is necessary to have as many conversant with the art as possible, if success is to be obtained.

All local points are encouraged to develop new methods and new applications of the art, same being checked by the supervisory organization before actual tests are made. All tests—both actual service and laboratory—are conjunctive. Indeed, we feel that it is the combination or co-operation of laboratory and practical service, research and tests, etc., that are responsible for many of the good results obtained.

The duties of the traveling supervisors and instructors, as their title implies, consist in instructing, supervising and checking, so that no operators are permitted to make important welds unless they have been approved by the welding supervisory organization.

As the work progressed, it became necessary and highly desirable to prepare a general welding instruction and standard practice, so that all who desired information on this subject, would have a means of acquiring same in the shortest possible time—also, so welding operators could acquire all necessary detailed instructions such as would permit a great shortening in the period of time required for making a kindergarten or student operator proficient enough to make revenue welds of the simplest kind and who within a few months after attaining this stage, would be able to make the most important welds with uniformly good results. This specification at the same time outlining the standard practice which should be followed for the various jobs or types of jobs, especially those with which difficulty might easily occur.

This standard practice and instruction when completed a few months ago (in the meantime we have had a couple of temporary practice and instruction books issued) as a result of two years' continued effort, was given the official identification of "specification No. 455-A." This specification is copyrighted and the various books issued are given an individual number, and when issued to the line, receipt is required for same, the books remaining the property of the company. These books are perpetual, and from time to time as revisions become necessary, they will be mailed out for inserting in the book in place of those parts that are annulled.

This specification is only about one-third up to date, and we hope during the coming winter to make up fully 50 per cent of the shortage, although developments are continuing so rapidly that this may not be possible. However, it is our intention to keep this specification as near up to date as our combined efforts will permit.

All of the departments and persons using the electric welding art are now so interested in its development and further application, since they have learned the tremendous financial savings that are effected, that we have extreme difficulty in keeping up with them.

Every arc welding job is a job in itself and if it is to be properly done so as to secure the best ultimate results, it should be fully covered by complete speci-

fication. It certainly is not within the scope of this paper to give a long list of detail specifications, but if we may be pardoned, we will at least give the table of contents from our copyrighted Rock Island lines electric arc welding instructions and standard practice, spec. 455-A, in an endeavor to outline our general plan of handling specifications:

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TRACK WORK
- Including Crossings, Frogs and Switches

IRON AND STEEL STRUCTURES
- Including Tanks

The following list includes many of the welding jobs that are performed as a regular practice. Under *tracks* are included crossings, frogs and switches. Under *structures* are included tanks and various types of fabricated steel structures, as well as some cast steel structures and a few cast iron structures.

Fire Box

Caulking edges welded
Some fireboxes have been completely welded
Grate studs welded to sheets
Fire door, fractures welded
Checked stay-bolt holes welded
Fire door, patches welded on
Studs welded to mudring
Front flue sheets, fracture welded
Crown sheet patches welded in
Sheets welded to mudring corners
Door sheet flange patches welded in
Side sheets, fractures welded
Nicholson Thermic Syphons welded in
Side sheets, patches welded in
Fire-door sheets welded in
Side sheets, welded in
Flues welded to flue sheets
Door collars welded

Boilers

Front flue sheet, fractures welded
Wash-out plug holes built up
F. C. B. stay-bolts welded
Smoke box patches welded in
Front flue sheets welded in
Superheater pipe, built up
Front end petticoat pipes welded
Spark arresters welded
Front end studs welded to flue sheet
Motion covers welded to running boards
Device attachment studs welded to boiler
Ash pans welded

Frames and Attachments

Belly braces, welded to frame
Binders, built up
Binders, liners welded to binders
Binders, wedge bolt hole plugger
Buckles welded to boiler
Buckle sheet, holes plugged
Buckle studs, welded to boiler
Bumper castings built up
Cab brackets welded to frame
Deck casting fracture welded
Equalizer fulcrum arms, fracture welded
Frames, built up
Frame, fractures welded
Frame posts welded in
Frame braces, holes plugged
Frame braces, welded to frame
Frame post fractures welded
Frame jaws, built up
Frame splice, holes plugged up
Front end casting, fractures welded
Guide blocks, built up
Guide yokes, built up
Guide yoke, fractures welded
Guide yoke bracket, fractures welded
Smoke arch brace, fractures welded
Tail pieces, built up

Cylinders

Cylinder, fractures welded
Front cylinder head, fractures welded
Broken bridges welded in

Running Gear Parts

Welding collars to crank pins
Crank pins built up
Driving boxes, built up
Driving box, fractures welded
Driving box, shoes and wedges, welding broken flanges
Engine truck pins, built up
Tires, spots built up
Driving wheel flanges built up
Tires, welding shims to tires
Trailer boxes, lugs welded on boxes
Trailer tires, built up
Trailer tires, spot welded to wheel center
Trailer yoke, fractures welded
Truck, fractures welded
Truck bolsters, built up
Truck frames, welded to center piece
Truck side frame, fractures welded
Wheel spoke, fractures welded

Connecting Rods

Main rods, built up
Main rod straps, built up
Rod straps, built up
Rod straps strips, welded to rod straps
Side rods, reinforcing of side rods
Side rods, collar-welded on side rods
Side rods, lateral plates welded on side rods

Cross Heads and Piston Rods

Cross heads, built up
Cross head, fractures welded
Gibs welded on cross heads
Cross head, holes plugged
Liners welded to cross heads
Cross head, pin built up
Cross head, pin holes built up
Straps welded on cross heads
Piston collars, built up
Piston rods, built up
Piston rod packing glands welded on

Valve Gear

Blade pins, built up
Combination lever, fractures welded
Eccentric arms, built up
Eccentric keys, built up
Link, holes plugged
Link blocks, built up
Link hangers, built up
Link pins, built up
Link saddles, built up
Motion pins, built up
Motion plate, fractures welded
Rocker arms, built up
Rocker arm, fractures welded
Tumbling shaft arm, fractures welded
Valve yokes, built up
Valve yoke lugs, built up
Valve yoke, stems built up

Steam and Exhaust Pipes

Dry pipes, fractures welded
Exhaust pipes, fractures welded
Nozzle stands, built up
Nozzle stand, holes plugged

Brake and Spring Rigging

Brake hanger, posts built up
Brake hangers, built up
Brake hangers, welded to frames
Equalizer fulcrum pins, built up
Equalizer jaws, built up
Equalizer stands, built up
Spring equalizer bushings, welded
Spring saddles, built up
Trailer spring guides, built up
Truck equalizers, built up

Tenders

Axle collars, built up
Truck bolster fractures
Side bearings, built up
Cisterns repaired by welding
Tank, fractures welded
Tank, goose necks welded

Cars

Couplers, fractures welded
Couplers, worn places built up
Couplers, increased size of butts on 5000
Couplers to M. C. B. standard by welding plates on to butts
Knuckles built up
Truck side frames welded
Truck and body bolsters welded
Repairs made by welding, to steel underframes
Cast steel truck frames welded
Car roofs on freight and passenger equipment welded
Passenger car steps and vestibules welded
Buffer stems and castings welded
Car body sheets welded
Axle generator suspensions welded
Battery and equipment box suspensions welded
Freight car carlines, braces, corner posts, door posts, gussets, etc., welded

Not Classified

Air pump pistons, built up
Bell crank, fractures welded
Bushings, spot welded
Chafing irons, built up
Chafing iron, steel plate welded in
Drawbar yokes, built up
Drill press shafts, built up
Dynamo door, fractures welded
Gascline engine cylinder, fractures welded
Grease cups, welded to rods
Link latch blocks, built up
Motor car casting, fractures welded
Reverse lever, fractures welded
Reverse lever latches, built up
Running board bracket, extensions welded on
Throttle latches, built up
Track work
Structures, iron and steel

* * *

The second part of Mr. Wanamaker's paper will appear in the November issue of the *Railway Electrical Engineer*.

On the Chilean State Railways

Making Screws Hold in Any Material

There has recently been placed on the market a device known as the Rawlplug which permits fixing an ordinary screw so that it will hold in metal, plaster, brick, concrete, slate or glass.

The Rawlplug is especially advantageous in railroad work for the original installation of interior trimming and fixtures for both steel and wooden coaches. Its use solves the problem of replacing screws in repair work on the interior of cars, as an old screw can be removed and again put in place permanently in the same hole by simply inserting a plug before placing the screw. The use of Rawlplugs in metal eliminates the need for tapping and thereby saves the time and labor required in doing this work.

Rawlplugs are hollow tubes of stiffened, longitudinal

Application of New Device

strands of jute fibre, so cemented that once in place they never crumble or pulp and are said to be unaffected by moisture or temperature changes. They are installed by first making a hole with any common drilling tool or with the Rawlplug tool in the material into which the screw is to be fixed, this hole being the proper size to receive the Rawlplug with a sliding fit. The plug is inserted into the hole and as the screw is turned home in the plug the fibre strands expand and enter every minute pore of the material, practically becoming an integral part of it. Rawlplugs are made in sizes to receive all screws from Number 1 to Number 32 and are furnished in ½ in., ⅝ in., ¾ in., 1 in., 1½ in. and 2 in. lengths. For convenience, tools for forming holes for the plugs are made in sizes to correspond with plug and screw sizes. For example, a Number 8 tool makes a hole of the proper size to receive a Number 8 plug and a Number 8 screw. Any type of drill may be used, however, for making the holes to receive Rawlplugs.

Tests conducted under actual working conditions showed that Rawlplugs withstood a direct pull, expressed in pounds, varying from 150 in plaster up to 600 in iron, or 1,250 in brick for a No. 14, 2 in screw. From this it is readily apparent that the holding property of the plug is ample to meet any conditions that would ordinarily be encountered in practice.

Rawlplugs are packed in boxes of 100 plugs of any one or assorted sizes. There are also various complete kits which include plugs, screws and tools. This product is manufactured by the Rawlplug Company, New York, which is represented in the railroad field by the Universal Packing & Service Company, Chicago.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

XV—Safety Car Lighting Equipment

THE Safety Car Lighting Equipment consists of a generator, driven by a belt from the car axle, a generator regulator panel, a lamp regulator panel mounted in a cabinet inside or under the car body, and a storage battery which is suspended in a box under the car body.

The fundamental principle of the Safety axle lighting system is a combination of constant current and constant voltage control which results in a tapered charge. For example, starting with a fully discharged battery, assume that the generator is delivering a charging current to the battery that is held constant at 65 amperes. This is termed current regulation. The counter-electromotive force of the battery increases as the battery charges, and accordingly the generator voltage increases a sufficient amount to compensate for the increase in battery e. m. f., thereby sending a constant current of 65 amperes through the battery. This increase of battery and generator voltage continues until the generator voltage has risen to approximately 39 volts for lead batteries and 43 volts for an Edison battery; then the voltage regulating coal goes into operation and holds the generator voltage constant at that amount. The operation is changed at this point from current to voltage regulation, because the counter-electro motive force of the battery keeps rising and as the generator voltage is limited to 39 volts for lead batteries and 43 volts for Edison battery, the current will gradually decrease or taper as the battery continues to charge. Thus, we start with a constant current charge and finish with a taper charge.

The lamp regulator is a device for controlling the voltage to the lamps, holding it constant between 30 and 31 volts when the battery or generator voltage is above that amount.

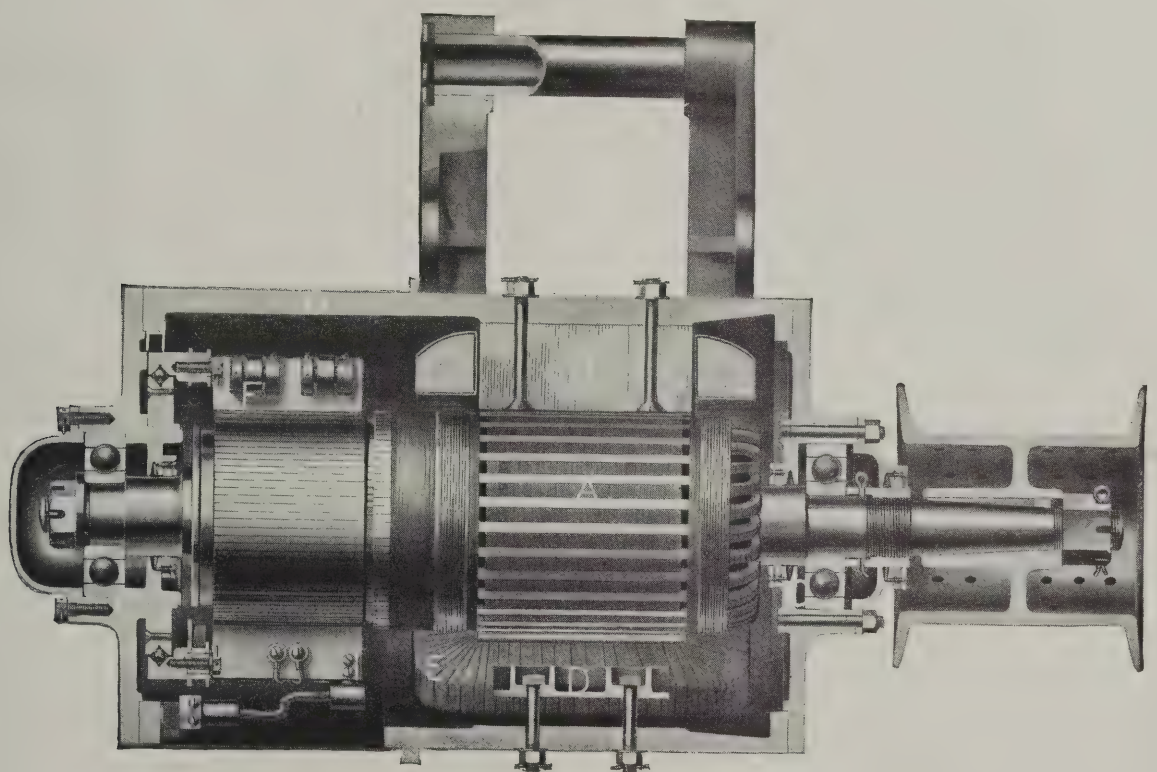


Fig. 1—Sectional View of Dynamo

Generator

The generator, a cross-section of which is shown in Fig. 1, is a four-pole, shunt-wound machine designed to give sparkless commutation with the varying speeds and varying loads met with in car lighting. The Safety generators are made for both body and truck suspensions. They are also made for high and low speed operation and in the following sizes: 1 kw., 2 kw., 2.6 kw., 3 kw., 4 kw. As far as possible, similar parts are made to be interchangeable among the different sized machines. This flexibility is a decided advantage.

The Safety generator consists of the following main parts: magnet frame, pole pieces, field coils and retainers.

armature, bearings, pole changer, brush rigging and brushes.

The magnet frame *G* is a one-piece steel casting; the supporting lugs being cast solid with the frame. The housing heads *C* which carry the bearings are made of cast iron and bolted to the magnet frame at each end. Hand holes, with water and dust proof covers, are provided at the commutator end for inspection purposes. The pole pieces, *B*, are of the laminated type, bolted to the magnet frame by through bolts with nuts and lock washers. This arrangement makes it impossible for the pole pieces and by field retainers *D* which are bolted to the magnet frame by through bolts with nuts and lock washers. The arrangement makes it impossible for the field coils to slip or wear by rubbing against the pole pieces. After being wound, the field coils are impregnated by the vacuum process with a material which makes them oil proof and water proof. The coil leads are flexible rubber covered wire soldered to the coil and securely taped six inches before coming through the insulation.

The armature, *A*, is form wound with conductors having heat proof insulation. The coils are held in the core slots by hard fibre wedges; no band wires being used except at the ends, outside of the pole pieces. The armature core is built up of transformer iron laminations, annealed and insulated after punching. They are assembled under heavy pressure between malleable iron plates at each end. Air spaces are provided in the core to secure cool running.

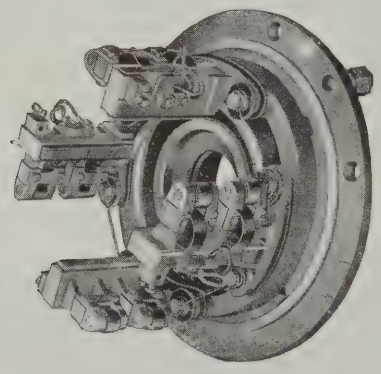


Fig. 2—Rotating Type of Pole Changer Mounted on Housing Head

The commutator bars are of hard drawn copper with liberal wearing depth and ample area to carry the maximum output of the generator.

The risers, to which the armature coils are connected, are integral with the bar. The mica insulation is of the best grade amber mica, having the same rate of wear as the commutator bars.

The armature shaft is made from high-grade steel accurately ground to size. All keys are secured to the shaft by screws, preventing any possibility of loose keys. The pulley in addition to having a tapered seat, is keyed to the shaft and locked with a castellated nut and cotter pin. The bearings for the armature shaft are annular ball bearings, of a type especially developed for this service. The bearings are either pressed on a hub which is keyed to the shaft, insuring ease of application and removal, or bolted directly on the shaft where hubs are not needed.

A space is provided around the bearings for grease for lubrication. Greased grooves and felt washers prevent the entrance of dirt into the bearings and the leakage of grease into portions of the dynamo where it should not go.

The pole changer, Fig. 2, is of the rotating type, the direction of the current from the dynamo being kept constant by rotating the brushes through an angle of 90 degrees whenever the direction of rotation of the armature is changed.

The four aluminum brush boxes are mounted on a brush rocker and are insulated from it by mica bushings and mica washers with large creepage surfaces. This brush rocker is mounted on a ball bearing and is free to rotate between two stops 90 degrees apart on the head. While running in one direction, the friction caused by the pressure of the brushes against the commutator holds the brush rocker against one of the stops, with the brushes in the proper position for the sparkless commutation for this direction of rotation. Reversing the direction of rotation causes the brush rocker to be turned over against the other stop, changing the position of the brushes 90 degrees. The generator then gives the same polarity, although the direction of rotation has been reversed.

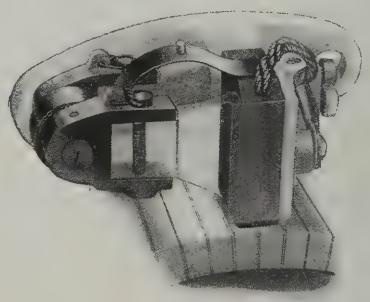


Fig. 3—Brush Box and Bfush Pressure Spring

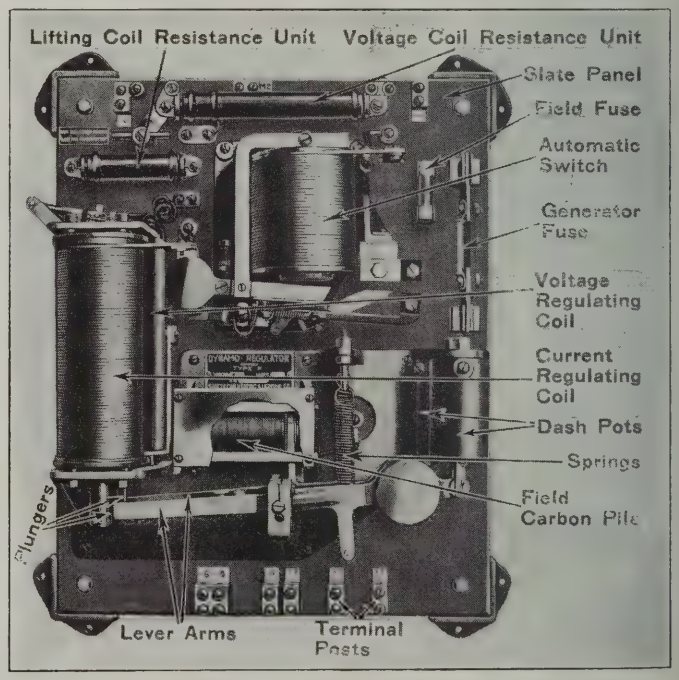


Fig. 4—Type "F" Dynamo Regulator

The brushes are made of carbon and provided with flexible copper pigtails to give positive contact with the brush box, as may be seen in Fig. 3. Each brush is pro-

vided with a separate pressure spring of such design that the pressure on the brush is constant until the brush reaches its limit of wear. These springs are spiral springs provided with a yoke so that the spring is set for the proper pressure before it is applied to the brush holder, and needs no further adjustment. Neither is there any danger of the spring being distorted in application.

current output of the generator, the design being such that a current of 65 amperes, for the 2.6 kw. machines, produces sufficient magnetism to lift the plunger and regulate the production of current.

On the front or current regulating lever arm is a finger projecting in toward the panel so placed as to be directly under a similar outward projecting finger on the rear or

Safety Generater Characteristics

	Underframe							Truck		
RATING	1 kw.	2 kw. P.R.R.	3 kw.	4 kw.	2.6 kw.	3 kw.	4 kw. Pullman	1 kw.	2.6 kw.	3
Amperes	25	50	75	100	65	75	100	25	65	75
Volts	40	40	40	40	40	40	40	40	40	40
Cut in speed R. P. M.	800	250	620	800	360	370	430	425	360	430
¾ low speed "	900	...	700	850	440	425	600	425	440	475
Full load speed "	1000	333	870	1000	650	500	725	550	650	600
Weight of generator without pulley	300 lb.	775 lb.	480 lb.	530 lb.	720 lb.	745 lb.	700 lb.	435 lb.	700 lb.	770 lb.
" armature	76 lb.	215 lb.	115 lb.	150 lb.	140 lb.	178 lb.	205 lb.	76 lb.	140 lb.	178 lb.

The table gives the characteristics, weights, etc., of the Safety axle lighting generators.

Generator Regulator

The generator regulator panel, Fig. 4, consists of a slate panel on which are mounted the automatic switch, field rheostat or carbon pile, two solenoid coils with their respective plungers and connecting lever arms, main and field fuses, and two resistance units.

The automatic switch consists of a fine wire shunt or lifting coil and a series or "kick off" coil of heavy copper ribbon, both surrounding an iron core which forms part of the magnet frame or yoke of the switch. At the bottom is pivoted a movable iron armature to which is attached the laminated conductor of the switch. The current flowing through the lifting coil induces in the iron core a magnetic flux, the value of which varies with the amount of current flowing through the coil. At a generator voltage of 33 volts the current through the lifting coil will have produced a magnetic flux of sufficient strength to lift upward the movable iron armature and bring its laminated conductor into contact with a stationary brass contact block on the switch frame. These two contact surfaces are protected by secondary carbon contacts so arranged as to be easily renewable. The lifting coil is connected in series with the small resistance unit which is located to the left of the automatic switch, and the circuit is then connected across the generator leads. The switch is set by the manufacturer to close at proper voltage, and no adjusting of the armature should be necessary.

The field rheostat or carbon pile shown at the center of the regulator panel, Fig. 4, is connected in series with the field circuit. The resistance of this carbon pile is automatically adjusted by movement of the plungers of the regulating coils. The shunt or voltage regulating coil located at the left of the regulator panel, controls a plunger whose lever arm acts directly on the carbon pile. This coil is connected in series with the large resistance unit located on the regulator panel above the automatic switch, the circuit then being connected across the generator leads. This resistance unit is so constructed that a small section of the resistance can be short circuited by a round brass rod fitted into suitable terminals.

The series regulating coil located at the left of the regulator panel in front of the voltage regulating coil is made of heavy copper ribbon through which flows the entire voltage regulating arm. These two fingers are separated by about 1/32 in. when the machine is inoperative, the position of the front arm then being determined by stop on the guide lever at the top of the solenoid frame. The stop should rest on the solenoid frame at this time, the position of the rear arm being determined by the length of the field carbon pile, this length depending upon the number of discs in the carbon pile.

Movement of the rear lever arm is transmitted directly to the carbon pile, pressure on which is then increased or decreased, depending upon the direction of plunger movement. The front lever arm, however, is not connected directly to the carbon pile, but its movement is transmitted through two projecting fingers to the rear lever arm, and thence to the carbon pile.

The movement of the two plungers and lever arms is dampened by two air dash pots, one connected to each arm. These dash pots are located at the right side of the regulator panel, Fig. 4, below the main fuse. In the side of each dash pot shell is drilled a small hole to permit escape of air.

The dash pot plungers are made of graphite. The dash pot shells are applied so that the vent hole points to the front, or nearly so, to facilitate inspection.

There are no adjustments to be made on the generator regulator panel other than to the field carbon pile and the short circuiting bar at the large resistance unit. The field carbon pile should contain enough carbon discs to give a separation of 1/32 in. between the fingers of the two arms when the machine is inoperative. The short-circuiting bar should be closed when a lead battery is used and open when an Edison battery is used. The springs connected to the lever arms are adjusted at the factory and therefore no adjusting is necessary.

Lamp Regulator

The Safety lamp regulator, Fig. 5, consists of two piles of carbon discs and an electro-magnet. The two carbon piles are connected in parallel and these two piles in parallel are connected in series with the lamps.

The electro-magnet automatically controls the pressure on the carbon piles. It consists of a shunt coil with an iron frame and a movable armature which is mounted on a crank block. The crank block is mounted on ball bearings and connected through a link to a pressure plate at the left end of the carbon piles, the right end plates of the carbon piles being stationary. On the left end of

the link is a corrugated nut by means of which the regulator adjustments are made. The movement of the armature is opposed by a spring, located directly back of the two carbon piles, and limited at each end by a stop. The two extreme positions of the armature correspond respectively to maximum and minimum pressure on the carbon piles.

The shunt coil of the electro-magnet is connected in series with the resistance unit located at the bottom of the lamp regulator panel, and the two are then connected across the lighting circuit so that they receive the lamp voltage. The flow of current through the magnet coil induces in the iron core a magnetic flux the value of which varies with the amount of current flowing through the coil. The pull of this flux on the armature is opposed by the pull of the spring, and the design is such that the pull of the spring and the pull of the electro-magnet will balance at 30.5 volts, thereby holding the lamp voltage constant at that value.

When the lamp voltage is high the magnet becomes stronger and pulls the armature down against the tension of the spring and reducing the pressure upon the carbons and increasing their resistance and bringing the lamp voltage back to normal. If the lamp voltage is low the magnet becomes weakened, the spring pulls armature back, and through the lever connection exerts enough

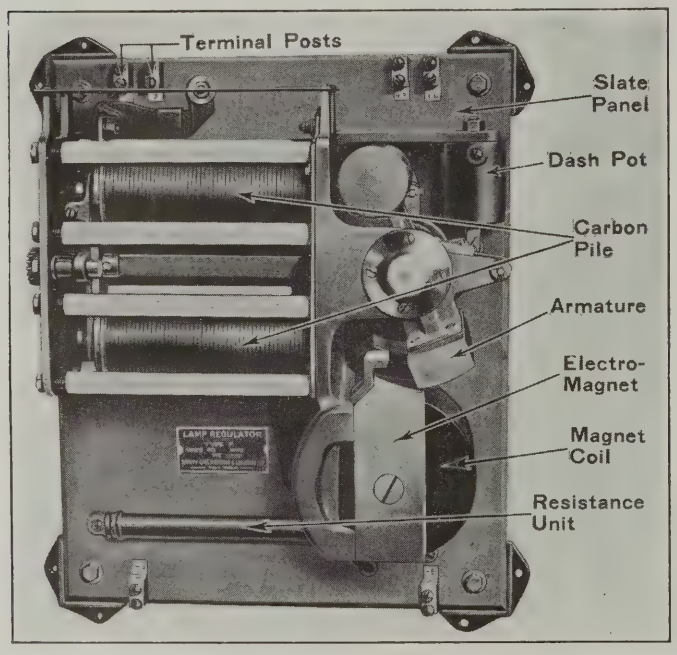


Fig. 5—Type F Lamp Regulator

pressure on the carbon piles to decrease their resistance and bring the lamp voltage back to normal.

An air dash pot of the same type as used on the generator regulator is employed on the lamp regulator. All co-operating parts of the dynamo and lamp regulators are built up as units on metal frames. These frames are secured to the slate panels, but the operation of the parts is independent of the mounting on the slate panels. Any parts may be removed without disturbing the slate panel and all connections are accessible from the front.

Voltage coils on both dynamo and lamp regulators are compensated for change in voltage, due to heating of the coil windings, by zero heat-co-efficient resistance placed in series with the coils.

Truck Suspension

A Safety truck suspended generator is shown in Fig. 6. The generator is mounted on the car truck outside the end sill and driven by a belt from a pulley on the car axle. Fig. 7 shows the general arrangement as applied to a standard form of a cast steel truck. The generator is mounted on a frame carried on two bars which are supported by the truck. The four generator lugs *C* are drilled for two supporting shafts *D*, which pass through the lugs and through the solid links *A*, the links being as long as the distance between the lugs. The lower end of each link *A* is supported by a shaft which passes through the link and supporting frame *B*. The shafts

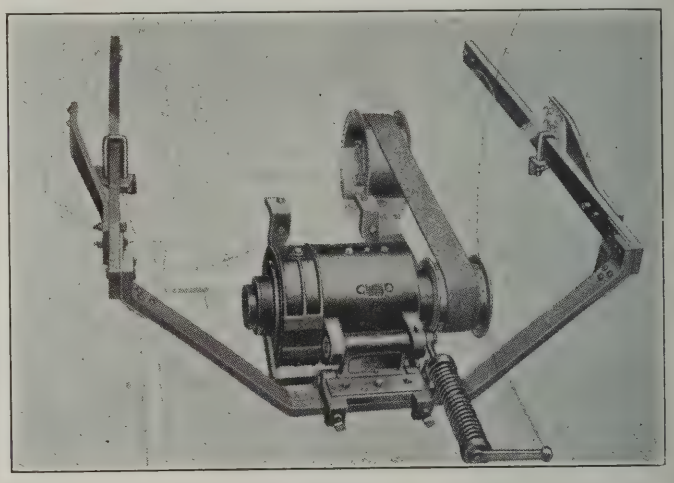


Fig. 6—Details of Truck Suspension

are locked in the lugs and supporting frame, the turning motion being confined to the bushings in links *A* on the shafts. This design provides a parallel suspension with points of support below the generator. The most important feature of this type of suspension is that it maintains constant belt tension, even when the belt stretches six inches. A tension spring bracket is bolted to the supporting frame and the tension rod *F* is secured to the end of the shaft *D* with a tension spring *E* held at a proper tension by the nut *G*.

Excessive belt strains, sometimes considered necessary to prevent the belt slipping when the tension decreases due to the belt stretching, are eliminated by this design. The nut *G* can not be screwed beyond a predetermined position on the rod *F*, which limits the amount of tension an operator or inspector can apply. When the links *A* are in a vertical position the belt tension is due only to the pull of the spring *E*. If the belt is of such a length that the links are inclined away from the truck, a part of the weight of the generator is added to the belt tension, the amount depending upon the distance the generator is off the vertical. In moving this distance the tension spring is somewhat released and gives less pull. The design is such that the loss of tension in the spring is equal to the additional tension due to the generator weight, and the total tension on the belt remains constant. If the links are inclined toward the truck, the weight of the generator is subtracted from the increased spring tension, and the belt tension is still maintained constant. All parts of the suspension subject to wear are lubricated —grease pockets with felt washers being provided.

The arrangement for lining up the generator with the car axle is simple and easily operated. The supporting

frame *B*, is secured to the suspension irons by six bolts *H*. The center bolt on the front side, or side farthest away from the truck, passes through a round hole in both the supporting frame and suspension iron. The holes in the supporting frame for the other five bolts are slotted so that the whole frame *B* can be swung around the center bolt. To line up the generator, it is only necessary to loosen up all the bolts, line up the machine by means of the two adjusting bolts *I*, and lock it securely in position by means of the bolts *H*.

Inspection of the dynamo or removal of pulley, armature, or heads whenever necessary is facilitated by the absence of long supporting bars giving clear space around the generator.

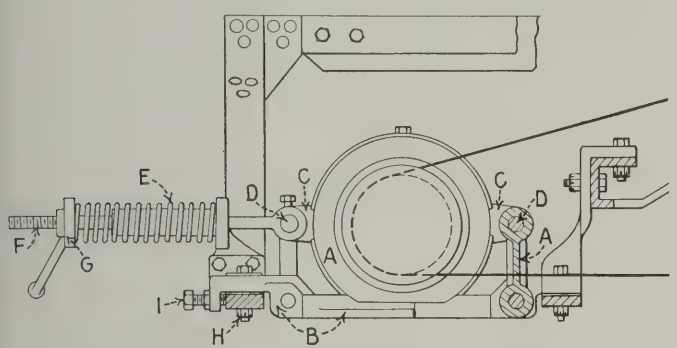


Fig. 7—Diagrammatic View of Truck Suspension

In the illustration, it can be also noted that one side of the suspension is supported by a cross member fastened to side irons extending from the truck ends, while the other side is held by a bracket bolted directly to the end sill. This is a good arrangement, since the weight of the generator is distributed between the truck and side irons instead of having all the weight of the generator carried by the side irons.

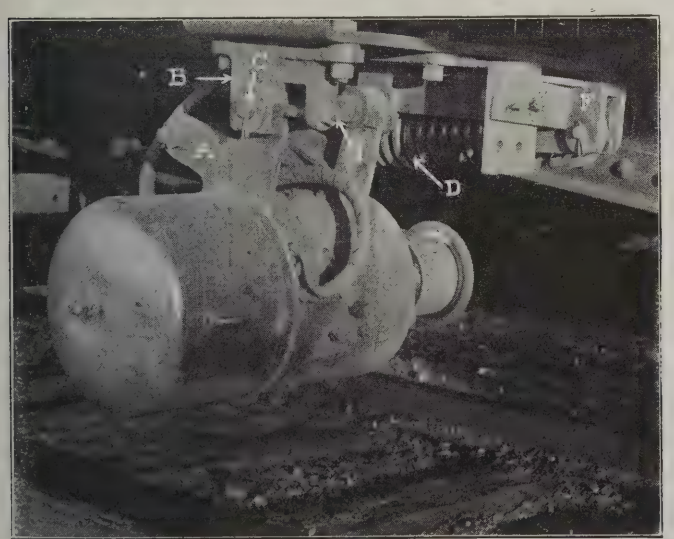


Fig. 8—Details of Body Suspension

Body Suspension

A Safety generator and body suspension is shown in Fig. 8. The generator lugs are pivoted to the suspension lugs *B* on the suspension casting by the shaft *C*. The suspension casting is bolted to a plate which is secured to the car underframe. The tension on the belt is applied by the weight of the generator and by the tension spring *D*, which engages at one end with lug *A* on the generator frame, and at the other end with the bracket *F*, fastened to the suspension casting. The parts are so designed that the sum of these two varying factors is constant. When the generator is hanging so that its center of gravity is directly under the supporting bar *C* the weight adds nothing to the belt tension but the spring *D* has its greatest effect, since the leverage on which the spring acts is greatest. If the generator is swung toward the truck the weight of the generator is giving tension, but the pull of the spring is decreased as the leverage is shortened; the sum of the two tensions being the same as in the first position. Ample latitude is provided between the two extreme positions of the generator to take care of belt stretch and the variation in distance between the generator and axle when the car is on a curved track.

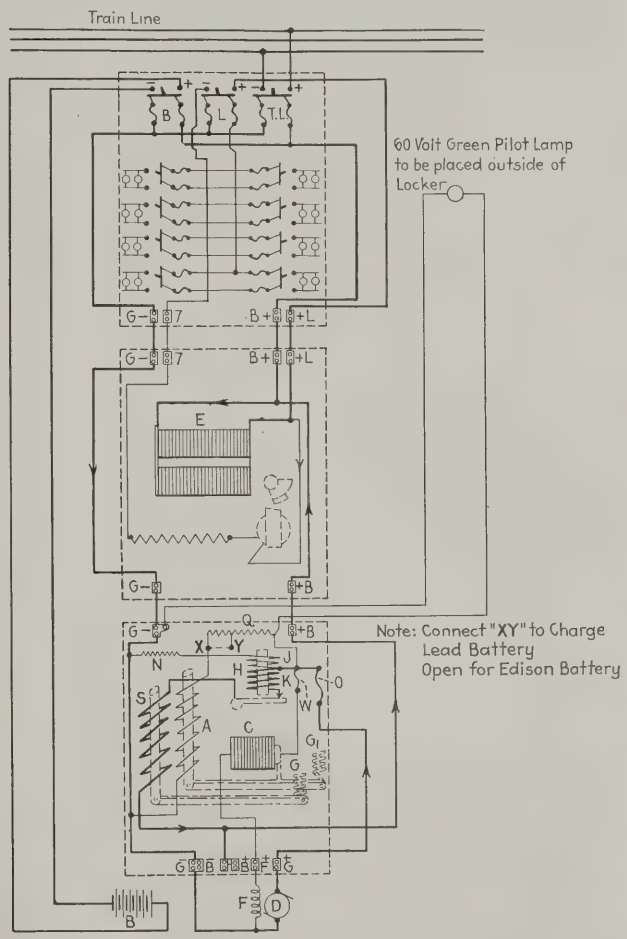


Fig. 9—Wiring Diagram of 40-Volt Type "F" Regulators

The tension spring *D* is assembled on a carrier, under the proper tension, so that to apply it to the suspension it is only necessary to slip the two pins through the holes in the carrier and corresponding holes in generator lug *A* and in the suspension bracket *F*.

Operation

Fig. 9 is a wiring diagram of the Safety Type F equipment and the operation is as follows:

When the car is standing and generator inoperative the current to the lamps is furnished by the storage battery. When the car is in motion the generator voltage will build up due to the residual magnetism of the field

pole pieces. At slow speeds there is generated in the armature a low voltage which forces a small amount of current through three parallel circuits, comprising the lifting coil *J* of the automatic switch, the field circuit, and the voltage regulating coil *A*.

While the voltage regulating coil circuit is alive at this time it remains inoperative until the battery is fully charged.

As the speed of the armature increases and the current in the field circuit increases the field magnetic strength, the generator voltage also increases until it reaches 33 volts, at which time the automatic switch *H* should close and connect the generator to the car wiring.

The instant the automatic switch *H* closes, all circuits become energized, the machine furnishing current for any lamps that may be turned on, but delivering only a small amount of current to the battery. As the speed increases the generator voltage rises and increases the battery charging current until the generator output reaches a value of 65 amperes for the 2.6 kw. equipment. Assuming the battery to be in a discharged condition, the generator voltage will now be about 35 to 38. The flow of this 65 amperes or total generator current through the series regulating coil *S* magnetizes the plunger of this solenoid and any increase in current above 65 amperes produces a magnetism of sufficient strength to lift the plunger and its lever arm, which movement is transmitted

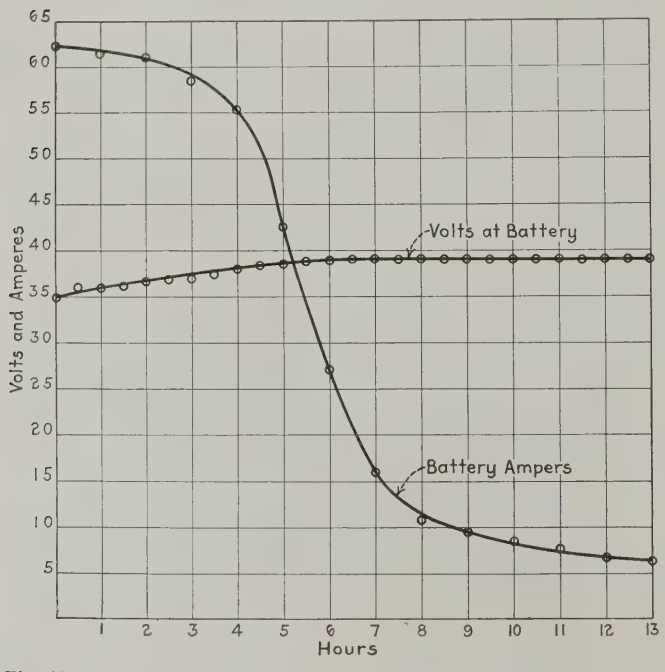


Fig. 10—Battery Charging Curve With Type "F" Dynamo Regulator

through the rear lever arm to the carbon pile *C*, increasing the resistance of this carbon pile and reducing the field magnetism until the current falls to its normal value of 65 amperes. In this way the generator output is held practically constant at all speeds when the battery is in need of charge.

From the instant the generator starts to build up, the voltage regulating coil *A* is alive but the current through it is not sufficient to produce the magnetism necessary to lift its plunger. However, the generator voltage gradually increases as the batteries become more fully charged, and this rise in voltage effects a corresponding gradual increase in the current through the coil, until the battery is fully charged, when the generator voltage will be about 39 volts for a lead battery and 43 volts for an Edison battery. The current through the voltage regulating coil *A* will then produce a sufficient magnetism to raise the plunger and decrease the pressure on the field carbon pile *C*, thus increasing the resistance of the field circuit, which reduces the magnetism in the pole pieces. Any tendency toward further rise in generator voltage is met by a further lifting of the shunt coil plunger so that the maximum voltage obtainable, when a lead battery is used, is 39 volts.

As the machine continues to operate after the batteries

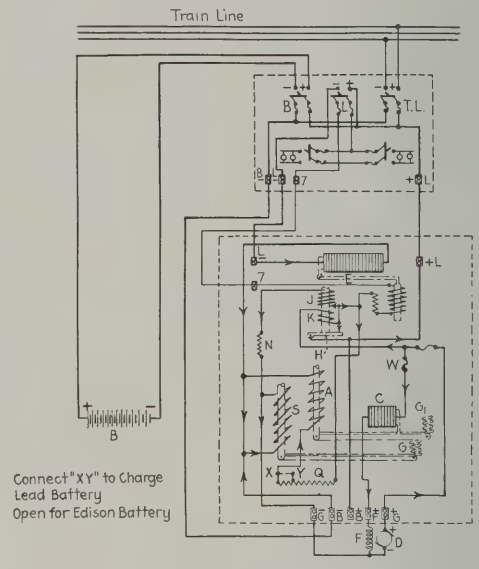


Fig. 11—Wiring Diagram for Type "F-1" Dynamo and Lamp Regulator

have been fully charged the voltage will remain constant at 39 and the current will gradually taper as the counter e. m. f. of the battery increases.

The voltage limit of 39 is for a lead battery. When Edison batteries are used a voltage of 43 is required for a full charge. This increase in regulated voltage is obtained by increasing the resistance of the voltage regulating coil circuit. To do this it is only necessary to slide the small brass rod *XY* to the left. This removes the short circuit from a section of the resistance unit *Q*. By increasing the resistance of the voltage regulating coil circuit in this manner the current in the circuit will not produce sufficient magnetism to lift the plunger and decrease the carbon pile pressure until the generator voltage has reached 43. The brass rod should be bridged across a section of the *Q* unit when a lead battery is used and should be disconnected when an Edison battery is used.

Fig. 10 is a lead battery charging curve of a Type F dynamo regulator. It may be noted that the charging is constant current when the battery is not fully charged, and constant voltage when the battery is fully charged.

Operation of the Lamp Regulator

Referring to the wiring diagram Fig. 9 it may be noted that the current to the lamps from the battery or generator passes through the two carbon piles *E* which are connected in parallel. It may also be noted that the regulator coil circuit is connected across the lamp circuit on the load side of the carbon piles *E*. Therefore the

rheostatic effect of the carbon piles governs both the lamps and the operating circuit of the regulator. The lamp regulator is adjusted for a lamp voltage of 30.5 volts. A sudden increase in speed will momentarily subject the lamp circuit to a higher voltage, but the same high voltage is impressed upon the operating coil, forcing increased current through this circuit, which action results in sufficient increase in magnetism to pull the armature of the regulating magnet down to the left and decrease the pressure on the carbon piles *E*. As this pressure is decreased, the voltage dissipated in the piles increases, with resultant reduction in lamp voltages. Therefore the voltage on the coil decreases with the lamp voltage, which effects a reduction in the coil current and magnetism until the voltage is reduced to 30.5 volts. When this has taken place the pull of the magnet and opposing spring will balance and no further movement will occur until there is a further change in voltage.

If the lamp voltage drops below normal, the reverse action takes place. The spring then exerts the stronger force and pulls the armature to the right, increasing the pressure in the carbon piles *E*. This reduces the voltage drop in the piles and increases the voltage on the lamps and the coil until the magnetic pull again balances the pull of the spring.

Safety F-1 Regulator

The Safety F-1 regulator has been designed for use on cars having small loads. Its operation is practically the same as the Type F, just described. Both lamp and generator regulator are mounted on the same panel. The wiring diagram of the F-1 equipment is shown in Fig. 11.

Safety F R Equipment

The Safety F R equipment is designed for non-passenger carrying cars, where the question of close lamp regulation is not regarded as an essential. Instead of a variable resistance in the lamp circuit, fixed resistances are used. These resistances are in series with the lamps when the dynamo is charging the battery, and short circuited when the lamps are lighted from the battery. The change is effected by a contactor operated by the main switch. The dynamo regulator is the F-1 with the exception that the main switch is of the solenoid type.

F-2 and Pullman Type Safety Equipments

The F-2 and Pullman Type Safety equipments were manufactured to comply with Pennsylvania Railroad and Pullman Specifications respectively and will be described fully in a later article.

Electric Motive Power for Paulista Railway*

Two passenger and two freight locomotives have been supplied by the Westinghouse Electric International Company for the Paulista Railway, Brazil.

The freight locomotives are of the six-axle type, with two six-wheel articulated trucks. There are six axle-mounted motors rating 280 hp. each at the one-hour rating. The motors are wound for 1,500 volts for operation two in series on 3,000 volts and are arranged for field control. Each motor drives its axle by a single flexible gear.

The passenger locomotives have a 2-4-0 + 0-4-2 wheel arrangement and each driving axle is equipped with a 580 hp., 3,000-volt twin motor and quill drive.

Freight and Passenger Motor Parts Interchangeable

The passenger and freight train weights and schedule speeds are such as to require locomotive horsepower ratings in almost exact ratio of four to three, so that by using eight armatures on the passenger locomotive and six on the freight locomotive it was possible to use the same identical motors in both services, except for the external frames. The passenger motors are in twin frames, while the freight motors are in axle and nose suspension frames, but the motors are identical electrically and all replacement parts, coils, complete armatures, field poles, brushes, armature bearings, etc., are interchangeable throughout. This is, of course, a tremendous

Two Baldwin-Westinghouse Electric Freight Locomotives for the Paulista Railway

*Abstract of an article on the Paulista Railway electrification by S. B. Cooper, general engineering department, Westinghouse Electric and Manufacturing Company.

operating advantage and is obtained without the sacrifice of fitness of type of each engine for its service. The freight locomotives operating at speeds up to 40 m. p. h. with comparatively light axle loads, have the mechanical simplicity inherent in axle-mounted motors and direct geared drive, while the passenger locomotives for speeds up to 65 m. p. h. have the advantages of high center of gravity and large proportion of spring-borne weight given by the quill drive.

Mechanical Construction

The frames are of solid slab steel with the openings drilled and burned out by torch. The brake rigging and equalizer parts are fitted with casehardened pins and bushings throughout, minimizing wear and facilitating replacement. The pedestal shoes are of bronze and the journal boxes are arranged for grease lubrication of the hub liners.

The control equipment has been worked out to give the greatest possible degree of simplicity consistent with good engineering and the proper degree of operating flexibility. All switches required to break heavy current are of the unit type mounted in two rows just below the main grid resistors. Motor combination circuits for motoring and regenerating are set up by cam switch groups and stabilizing resistor connections for regeneration are made by smaller unit switches without blowout coils.

Continental type couplers with take-up screws are used on passenger cars, but only open links on freight equipment. For this reason it is particularly desirable to have a high degree of flexibility and smoothness in the control. This is accomplished by having three motor combinations of six, three and two armatures in a series on the freight locomotives, giving, with field control notches, six running speeds. The main handle on the master controller has 18 positions, giving a total of 54 notches. On the passenger locomotives the armatures are connected eight, four and two in series, giving six running speeds and 54 notches.

Regeneration is provided for in all three combinations, with 13 notches in each combination, giving a particularly wide range of regenerating speeds, a most desirable feature with the various classes of trains and varying grade conditions existing on the Paulista.

The brake equipment consists of a combination of air and vacuum brakes. The space requirements for the cylinders made it impossible to use vacuum brakes on the locomotives, so they are equipped with air brakes. The control of the brakes is so arranged that air on the locomotive and vacuum brakes on the train is handled from a single valve with uniform rates of application and release. An independent straight air valve is provided for the separate control of the locomotive brakes as desired, thus making it possible to shut down the exhauster during light engine or switching movements.

The auxiliary equipment is simply arranged; a single high voltage auxiliary motor-generator set furnishes power for control, lights, motor excitation during regeneration and for the blowers, compressor and vacuum exhauster. The motors driving the exhauster and blowers are practically identical. The control and auxiliary equipment throughout is the same on the freight and passenger locomotives, excepting for such detailed differences as are required for the control of six and eight armatures respectively.

Provision for Future Conditions

The traffic on the Paulista system is growing at a very healthy rate and even with double track it will not be many years before track capacity becomes a serious consideration. It seems probable that by that time both the Sao Paulo Railway and the Paulista Company will change over to M. C. B. type couplers and therefore be able to handle much larger trains. With this end in view, these locomotives have been equipped for multiple operation so that they can be double-headed with a single crew and handle 1,400-ton trains instead of 700. The bumper castings have been so designed that M. C. B. couplers can be very easily applied to replace the Continental type.

Electric Passenger Locomotive

General Dimensions and Ratings

	Freight	Passenger
Wheel arrangement	0-6-0+0-6-0	2-4-0+0-4-2
Rigid wheelbase	14 ft. 0 in.	8 ft. 4 in.
Total wheelbase	37 ft. 0 in.	41 ft. 2 in.
Length over buffers	50 ft. 2 in.	52 ft. 11 in.
Total height over cab roof	12 ft. 7 in.	12 ft. 7 in.
Total height with trolley down	14 ft. 10 in.	14 ft. 10 in.
Diameter driving wheels	40 in.	63 in.
Total weight	234,000 lb.	282,000 lb.
Weight on drivers	234,000 lb.	206,000 lb.
Number of motors	6	4
Gear ratio	16:63	28:86
One hour rating, per motor	280 hp.	560 hp.
Locomotive ratings—short field:		
Horse power (one hour)	1,680	2,240
Tractive effort	29,400 lb.	19,400 lb.
Speed, m. p. h.	21.4	43.2
Horse power (continuous)	1,350	1,800
Tractive effort	21,600	14,300
Speed, m. p. h.	23.4	47.2
Tractive effort at 25% adhesion, lb.	58,500	51,000
Maximum safe speed, m. p. h.	40	65

The more important ratings and dimensions are shown in the table. Ratings are on the basis of the A. I. E. E. rules throughout, the continuous rating being based on 85 deg. C. rise by thermometer, or 105 deg. C. rise by resistance, thus giving conservative total temperatures with the high air temperatures encountered at certain seasons in Brazil.

The freight locomotives are now in Brazil ready for service, and the passenger locomotives have been completed and shipped from the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company.

Electrical Exports from the United States to Brazil during the first seven months of 1921 have amounted to $4,827,455 as compared with the total electrical exports of 1920 which totaled $6,340,841. At the present rate Brazil should import from the United States during this year electric materials to the extent of about $8,000,000.

Electrification Report of the A. E. R. A.

Committee Defines Heavy Electric Traction; Locomotives and Multiple Unit Cars Compared

THE report of the Committee on Heavy Electric Traction of the American Electric Railway Association was presented at the annual convention, recently held at Atlantic City, N. J. The committee outlined the work in progress by the A. E. R. A. and other societies in America interested in heavy electric traction, and suggested that much of the present duplication of work should be done away with. The term heavy electric traction was defined as it applies to locomotives and multiple-unit equipment, a progress report on electric switching locomotives was made, comparative advantages of locomotives and multiple-unit cars were outlined and much data presented in the form of charts, tables, and a bibliography. An abstract of the report follows:

For the coming year the activities of the Committee on Electricity of the American Railway Engineering Association will be in general a continuation of the investigation of the problem of electrical interference, and a study of the water power situation in the United States. An attempt will be made to standardize and compile specifications on overhead transmission line construction, as well as on such material as porcelain insulators; friction, rubber and other tapes; knife and snap switches, etc.

In this connection there is presented below a resume of activities of other technical organizations interested in heavy electric traction.

THE INTERNATIONAL RAILWAY CONGRESS is collecting, through Mr. George Gibbs, chief engineer of electric traction Long Island Railroad, for its report of 1922, general data on installation and operation of electrified railways. It is understood that the information will probably be tabulated and attention called to the advances made in the art of railway electrification since the last report of 1911. A great deal of very valuable information is being collected and the report promises to be of great interest.

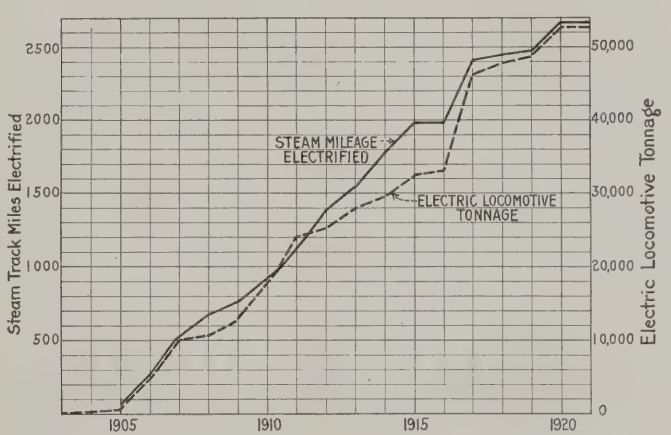
THE NATIONAL ELECTRICAL LIGHT ASSOCIATION, Committee on Electrification of Steam Railroads, has issued a brief general statement of progress and tendencies in electrification. This is an interesting report of a general nature in which are noted the advantages of electrification and the necessity of allowing the railroads an opportunity to establish financial credit for electrifying. The N. E. L. A. has also issued a report on inductive interference, which, while it is of a general nature, is, nevertheless, of considerable interest to those responsible for electric operation of railroads.

THE AMERICAN RAILWAY ASSOCIATION, Mechanical Section, has the following electrification assignments: 1. Design of multiple-unit cars, passenger locomotives and freight locomotives. 2. Maintenance instructions of electric equipment. Each member of the committee has been requested to furnish as complete information as possible on modifications which have been found necessary in existing electrical equipment. A sub-committee of which J. V. B. Duer, electrical engineer, Pennsylvania, is chairman is engaged in the preparation of a set of recommendations covering maintenance instructions for employees engaged in maintaining electrical equipment. It is understood that no report may be issued by this committee this year, on account of financial conditions in the country.

THE ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS has co-operated with your committee through its heavy traction committee, of which J. R. Sloan, chief electrician, Pennsylvania, is chairman. The activities of that organization for the coming year are as follows: 1. Revise last year's report giving data on locomotives, track and transmission in accordance with corrected figures received from the railroads. 2. Extend the data by including multiple unit equipment cars. 3. Show profiles of the various railroads. 4. Show typical third rail and catenary construction. The Association of Railway Electrical Engineers has issued questionnaires and obtained considerable data which will be of value.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS has confined its activities in the matter of heavy traction, this year, to work in connection with the Super-Power Survey in determining the power requirements of railroads in the North Atlantic district.

The above information is presented with the thought that it indicates considerable duplication of effort in the heavy traction field. Furthermore, it is evident that considerable valuable work is being accomplished by other



Growth of Steam Railroad Mileage Electrified and Electric Locomotive Tonnage in Heavy Traction Service in United States and Canada

technical organizations which would be of interest to the members of the American Electric Railway Association; and it is possible that the work of this association would be of interest to the membership of other organizations. It is recommended, therefore, that an effort be made to co-ordinate the activities of various organizations with the view of eliminating so far as possible overlapping and duplication and of making more valuable to the profession the work of the technical committees, much of which represents considerable sacrifice of time and energy on the part of the members of the several committees.

Heavy Electric Traction Defined

There is presented herewith, tabulated information showing the characteristics of the electric locomotives

MULTIPLE UNIT TRAINS OF NORTH AMERICA (Heavy Service)

Company No.	Railroad	Dimensions			Wheel base		Motors		Gear ratio	One hour rating forced ventilation			Seating capacity	Key No.
		Length over all	Width over all	Height top rail to highest point trolley down	Rigid	Total	No.	Type		Total T. E. (lbs.)	Speed M. P. H.	H. P. each motor		
1	Boston Elevated Ry. Co	46′–7¼″	8′–9¼″	12′–6½″	6′–0″	38′–3½″	2	W-301	18:59	6,000	22	175	48	1-a
		46′–7¼″	8′–9¼″	12′–6½″	6′–0″	38′–3½″	2	GE-259 P	60:17	4,775	18	120	48	1-b
		46′–7¼″	8′–9¼″	12′–6½″	M-6′–1″, T-6′–0″	38′–4″	2	GE-259 B	60:17	4,775	18	120	48	1-c
		46′–7¼″	8′–9¼″	12′–6½″	6′–0″	38′–3½″	2	W-301	18:59	6,000	22	175	48	1-d
		46′–7¼″	8′–9¼″	12′–6½″	6′–0″	38′–3½″	2	W-301	18:59	6,000	22	175	48	1-e
		46′–7¼″	8′–9¼″	12′–6½″	M-6′–1″, T-6′–0″	38′–3½″	2	GE-259	60:17	4,775	18	120	48	1-f
		69′–6½″	9′–6″	12′–8½″	M-7′–0″	57′–6″	2	W-300	20:63	8,000	21	220	72	1-g
		69′–6½″	9′–6″	12′–8½″	T-6′–0″	57′–6″	2	GE-212	63:20	8,600	18	225	72	1-h
		69′–6½″	9′–6″	12′–8¼″	"	57′–6″	2	W-577	20:63	6,900	21.5	200	72	1-i
2	Brooklyn Rapid Tranist Co						2	W-50				180		2-a
							2	W-300				220		2-b
		67′–0″	10′–0″	12′–2″	6′–8″	50′–4″	2	GE-248						2-c
3	Canadian Nat'l Rys. (Mt. Royal)	67′–6″	10′–3″	15′–0″	7′–0″	53′–0″	4	GE-239	66:22	9,600	23	150	68	3
4	Chicago Elevated Ry. Co	47′–0½″	8′–9″	12′–10″	6′–6″	43′–0″	2	W-109				180	48	4-a
		47′–3″	8′–8″	12′–8″	6′–1″	40′–1″	2	W-121	17:58			100	52	4-b
							2	W-114				175		4-c
		46′–7½″	8′–8″	13′–5″	6′–0″	38′–8″	2	W-302				140	48	4-d
		48′–6½″	8′–8″	12′–3½″	6′–8″	40′–0″	2	W-567	17:60	6,400	20	172	52	4-e
5	Chicago, North Shore & Milwaukee R. R.	46′–0″	9′–1½″	13′–7½″	6′–0″	31′–10″	4	GE-74	67:22	4,918	20.6	65	46	5-a
		52′–3″	8′–8″	13′–10 3/16″	6′–0″	35′–10″	4	GE-73	52:22	5,200	22	75	54	5-b
		56′–1″	8′–8″	12′–10½″	7′–0″	39′–8″	4	W-577	54:22	5,120	41	140	56	5-c
		56′–1″	8′–8″	12′–10½″	7′–0″	39′–8″	4	W-557	23:57	7,800	27	140	56	5-d
6	Erie R. R. Co	53′–3″	8′–6″	15′–6″	6′–8″	36′–0″	4	W-132	20:63					6-a
		67′–3″	9′–8″	16′–1½″	7′–0″	49′–0″	4	W-132-C	20:63					6-b
7	Hudson & Manhattan R. R	48′–3″	8′–11 3/16″	12–0″	M-0′–6″, T-5′–6″	39′–5½″	2	GE-76	62:19	7,200	16	150	44	7-a
		48′–5″	8′–11½″	11′–8 7/16″	"	39′–5½″	2	GE-76	62:19	7,200	16	150	44	7-b
		48′–5″	8′–11½″	11′–8 7/16″	"	39′–5½″	2	GE-76	62:19	7,200	16	150	44	7-c
		48 –3½″	8′–8½″	11′–8½″	7′–0″	40′–0″	2	GE-212-C	53:22	6,740	27	225	44	7-d
		51′–3½″	8′–11½″	11′–9 7/16″	M-6′–6″, T-5′–6″	39′–5½″	2	GE-259	60:17	4,775	18	120	44	7-e
8	Interborough Rapid Transit Co	51′–0½″	9′–0½″	12′–0″	M-6′–8″, T-5′–6″	42′–3″	2	W-86	19:63	7,500	19.5	200		8-b
		47′–0½″	8′–9½″	13′–4″	M-6′–0″, T-5′–0″	38′–8″	2	W-300	20:63	8,000	21	220	48	8-j
		47′–0½″	8′–9½″	13′–4″	"	38′–8″	2	W-302	16:61	5,800	18	140	48	8-k
		51′–0½″	9′–0½″	12′–0″	M-6′–8″, T-5′–6″	42′–3″	2	W-302	17:60	5,400	19.5	140	48	8-l
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	W-333	16:61	4,200	21	115	48	8-m
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	W-577	21:62	6,500	23	200	48	8-v
		47′–0½″	8′–9½″	13′–3¼″	M-6′–0″, T-5′–0″	38′–8″	2	GE-66A	61:16	6,600	14.5	125		8-a
		47′–0½″	8′–9½″	13′–3¼″	"	38′–8″	2	GE-69-B	63:20	8,100	18.4	200		8-c
		51′–0½″	9′–0½″	12′–0″	M-6′–8″, T-5′–6″	42′–3″	2	W-86-B	63:19					8-d
		47′–0½″	8′–9½″	13′–3¼″	M-6′–0″, T-5′–0″	38′–8″	2	GE-211-A	61:16	5,460	18.9	160	48	8-e
		47′–0½″	8′–9½″	13′–3¼″	"	38′–8″	2	GE-212-A	63:20	8,760	20.4	235	48	8-f
		51′–0½″	9′–0½″	12′–0″	M-6′–8″, T-5′–6″	42′–3″	2	GE-212-A	63:20	8,760	20.4	235		8-g
		47′–0½″	8′–9½″	13′–3¼″	M-6′–0″, T-5′–0″	38′–8″	2	W-300	64:20				48	8-h
		47′–0½″	8′–0½″	13′–3¼″	"	38′–8″	2	W-302	61:16					8-i
		51′–0½″	9′–0½″	12′–0″	M-6′–8″, T-5′–6″	42′–3″	2	GE-240–C	60:16	3,120	22.7	94	48	8-n
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	W-302-F	60:17				48	8-o
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	GE-259-A	61:16	4,040	22.6	120		8-p
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	W-333	61:16					8-q
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	GE-260–A	62:21	6,250	23	195	48	8-r
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	GE-259–A	61:16	4,040	22.6	120		8-s
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	GE-260–A	62:21	6,250	23	195	48	8-t
		51′–0½″	9′–0½″	12′–0″	"	42′–3″	2	W-577	62:21					8-u
9	Long Island R. R. Co							W-113				210		9-a
								W-308				210		9-b
10	Metropolitan West Side Elevated Ry (Chicago and Oak Park).	47′–9½″	8′–9″	12′–10″	5′–0″	38′–7″	2	GE-2,000	3:17	4,000	21	135	40	10-a
		47′–0½″	8′–9″	12′–10″	6′–0″	39′–7″	2	GE-55	55:18	7,600	16	160	48	10-b
		47′–0½″	8′–9″	12′–10″	6′–6″	21′–1″	2	W-109	3:17				48	10-c
		48′–6½″	8′–8″	12′–3½″	6′–8″	40′–0″	2	GE-243	60:17	6,400	19	155	52	10-d
11	New York Central R. R	62′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-59-C	49:26	5,700	27	195	70	11-a
		62′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-60-C	49:26	5,700	27	195	70	11-b
		62′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-60-C	49:26	5,700	27	195	70	11-c
		62′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-60-C	49:26	5,700	27	195	70	11-d
		62′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-69-C	49:26	5,700	27	195	70	11-e
		63′–7″	9′–9″	14′–10″	7′–0″	40′–5″	2	GE-69-C	49:26	5,700	27	195	74	11-i
		62′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-69-C	49:26	5,700	27	195	42	11-f
		63′–7″	9′–9″	14′–10″	7′–0″	46′–5″	2	GE-69-C	49:26	5,700	27	195	46	11-j
		69′–5″	9′–9″	14′–10″	8′–0″	52′–10″	2	GE-260–B	51:18	6,000	24	195	82	11-k
		69′–5″	9′–9″	14′–10″	8′–0″	52′–10″	2	GE-260–B	51:18	6,000	24	195	82	11-l
		61′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-59-C	49:26	5,700	27	195	0	11-g
		61′–2″	9′–9″	14′–10″	7′–0″	45′–0″	2	GE-69-C	49:26	5,700	27	195	0	11-h
12	New York, New Haven & Hartford	71′–11″	9′–8¾″	14′–3″	8′–0″	55′–7½″	4	GE-A 613B	67:23	8,800	23	150	76	12-d
		70′–5″	9′–7½″	14′–3″	8′–0″	55′–7½″	4	GE-A 613B	67:23	8,800	23	150	76	12-b
		70′–10½″	9′–7½″	14′–3″	8′–0″	55′–7½″	4	W-156	23:76				76	12-a
		70′–10¾″	9′–7½″	14′–3″	8′–0″	55′–7½″	4	W-402-D	27:73				76	12-c
		71′–11″	9′–8¾″	14′–3″	8′–0″	55′–7½″	4	W-402-D	27:73				76	12-e
		71′–11″	9′–8¾″	14′–3″	8′–0″	55′–7½″	4	W-412	22:58				76	12-f
		71′–11″	9′–8¾″	14′–5″	8′–0″	55′–7½″	4	GEA 613D	77:23	10,120	20	150	76	12-g
		71′–11″	9′–8¾″	14′–3″	8′–0″	55′–7½″	4	W-409-D	27:73				76	12-h
		71′–11″	9′–8¾″	14′–3″	8′–0″	55′–7½″	4	W-417	19:61				76	12-i
13	New York, Westchester & Boston	72′–0¾″	9′–10″	14′–0¾″	8′–0″	55′–7½″	2	W-409-B	25:68				78	13
14	New York Municipal Ry	67′–0″	10′–0″	12′–2″	6′–8″	50′–4	2	GE-248	61:22	5,300	22.5	160	90	14
15	Northwestern Elevated R. R	46′–7½″	8′–8″	13′–5″	6′–0″	38′–8″	2	GE-55	56:17	7,600	16	160	48	15-a
		46′–7¾″	8′–8″	13′–2″	6′–0″	38′–8″	2	GE-211–B	58:17	7,600	16	160	48	15-b
		46′–7¾″	8′–8″	13′–5″	6′–0″	38′–8″	2	W-302	3:41				48	15-c
		48′–6¼″	8′–8″	12′–3½″	6′–8″	40′–0″	2	GE-243	60:17	6,400	19	155	52	15-d
		48′–0¼″	8′–8″	12′–3½″	6′–8″	40′–0″	2	W-567	60:17				52	15-e
16	Pennsylvania R. R. (New York)	64′–0¾″	9′–11½″	13′–3½″	7′–0″	46′–9″	2	W-308	25:48	*5,100	*33	*225	72	16-a
		64′–0¾″	9′–11½″	13′–3½″	7′–0″	46′–9″	4	W-308	25:48	*5,100	*33	*225	52	16-b
	Pennsylvania R. R. (Philadelphia)	64′–0½″	9′–11½″	15′–0¾″	M8′–8″ T8′–0″	48′–1″	2	W-412-A	24:55	3,800	44.5	225	72	16-c
		64′–0½″	9′–11½″	15′–0¾″	M8′–8″ T8′–0″	48′–1″	2	W-412-A	24:55	3,800	44.5	225	52	16-d
		64′–0½″	9′–11½″	15′–0¾″	M8′–8″ T8′–0″	48′–1″	2	W-412-A	24:55	3,800	44.5	225	—	16-e
		64′–0½″	9′–11½″	15′–0¾″	M8′–8″ T8′–0″	48′–1″	2	W-412-A	24:55	3,800	44.5	225	72	16-f
		64′–0½″	9′–11½″	15′–0¾″	M8′–8″ T8′–0″	48′–1″	2	W-412-A	24:55	3,800	44.5	225	—	16-g
17	Philadelphia Rapid Transit Co	49′–7″	8′–8″	12′–6″	6′–7″	40′–2″	2	GE-66	61:17	5,200	18	125	48	17-a
		49′–7″	8′–8″	12′–6″	6′–9″	40′–2″	2	GE-66	61:17	5,200	18	125	48	17-b
		49′–7″	8′–8″	12′–6″	6′–8″	40′–2″	2	GE-66	61:17	5,200	18	125	48	17-c
		49′–7″	8′–8″	12′–6″	6′–9″	40′–2″	2	GE-66	61:17	5,200	18	125	48	17-d
		49′–7″	8′–8″	12′–6″	6′–8″	40′–2″	2	GE-66	61:17	5,200	18	125	48	17-e
		49′–7″	8′–8″	12′–6″	6′–8″	40′–2″	2	GE-222	61:17	5,900	18	140	48	17-f
18	Southern Pacific Co. (O. A. & B. Division)	72′–10½″	10′–4″	15′–7″	7′–0″	52′–0″	4	GE-259	16:61					17-g
19	South Side Elevated R. R	47′–1″	8′–8″	12′–8″	5′–6″	38′–2″	4	GE-207	64:17	11,680	18	140	116	18
		47′–3″	8′–8″	12′–8″	5′–6″	38′–5″	2	GE-57-B	2:05	2,450	16	50	46	19-a
		47′–3″	8′–8″	12′–8″	5′–6″	38′–5″	2	GE-73-A	21:68	2,500	16	75	44	19-b
		47′–3″	8′–8″	12′–8″	6′–1″	40′–1″	2	W-121	3:41				52	19-c
20	West Jersey & Sea Shore R. R	48′–0¾″	8′–8″	12′–3½″	6′–8″	40′–0″	2	GE-243	60:17	6,400	19	155	52	19-d
		55′–2½″	10′–0¾″	15′–3 5/16″	7′–0″	40′–0″	2	GE-69-C	46:29	4,600	32.4	200	58	20-a
		55′–2½″	10′–0¼″	15′–3 5/16″	M-7′–3″, T-7′–0″	40′–1½″	2	GE-69-C	46:29	4,600	32.4	200	58	20-d
		55′–2½″	10′–0¾″	15′–3 5/16″	"	40′–1½″	2	GE-69-C	46:29	4,600	32.4	200	58	20-e
		64′–0¾″	9′–11½″	15′–1″	8′–0″	47′–9″	2	GE-212-F	52:23	6,000	29.3	235	72	20-g
		64′–0¾″	9′–11½″	15′–1″	8′–0″	47′–9″	2	GE-212-F	52:23	6,000	29.3	235	72	20-h
		55′–2½″	10′–0¾″	15′–3 5/16″	7′–0″	40′–0″	2	GE-69-C	46:29	4,600	32.4	200	0	20-b
		55′–2½″	10′–0¼″	15′–3 5/16″	M-7′–3″, T-7′–0″	40′–1½″	2	GE-69-C	46:29	4,600	32.4	200	0	20-c
		64′–0½″	9′–11½″	15′–1″	8′–0″	47′–9″	2	GE-212-F	52:23	6,000	29.3	235	0	20-f

* Natural Ventilation.

now in use on trunk line railroads in North and South America. Data of interest has also been compiled in connection with multiple-unit equipment at present in operation. Data on European railroad electrification is in process of compilation, but has not been made available for publication this year.

The Paulista Railroad in South America has been included in the tabulated data. This railroad is not in operation at the writing of this report but it will be completed before the end of the present year. Locomotives for this project have been furnished by both the Westinghouse and General Electric Companies.*

In order to limit the tables to reasonable size it was decided to include only those locomotives which weigh more than 80 tons, and multiple-unit equipment normally operated in trains of four cars or more. It has been the thought of your committee that this general classification will include equipment normally considered as applying to heavy traction. It is realized that there are instances where it is desirable to include equipment which does not strictly conform to these limits. In such cases an arbitrary departure from the limits set has been made. In some instances of multiple-unit equipment the motors were supplied by one manufacturer and the control equipment by another.

Electric Switching

The use of electric switches in heavy railroad operation has been relatively slight as compared with that of electric road engines. Two railroads only, the New York, New Haven & Hartford and the Chicago, Milwaukee & St. Paul have developed electric locomotives in connection with their electric operation especially for switching service. The New York Central, the Norfolk & Western and the Butte, Anaconda and Pacific Railroad and the Pennsylvania Railroad at New York City do considerable switching with their electric road locomotives but naturally these engines are not especially adapted to switching requirements. Inasmuch as satisfactory records are not available in regard to electric switching it is impossible at the present time to present data either as to relative costs or as to the number of cars switched by electric as compared with steam locomotives under same conditions.

The Butte, Anaconda & Pacific Railway Company has developed a tractor truck in connection with their electric switching at Butte. These tractors consist of a truck, weighing about forty tons, with motors, which may be coupled to a road locomotive unit. The current collection and other functions are taken care of by the locomotive, the auxiliary equipment being connected by jumpers. The use of the auxiliary tractor is said to give fifty per cent more tractive effort, at about two-thirds the normal speed, when connected in series with a single locomotive. The device also accomplishes considerable saving in wear and tear on the resistance grids.

A very large number of light electric locomotives weighing from twenty to sixty tons are in operation at the present time which are doing valuable work in industrial switching, interurban freight service, etc. This type of engine is now practically standardized just as street railway and interurban equipment has become standardized. The locomotives operate usually at either 600 or 1,200 volts direct current.

Light storage battery locomotives have been employed to some extent for switching. A storage battery unit for yard switching is proposed and designs are under way. Certain advantages might be obtained by the use of a storage battery locomotive for switching, notably in territory where the passage over any individual track is infrequent.

Locomotives or Multiple-Unit Trains?

In suburban electrification of railroads the application of multiple-unit equipment provides a solution for many important problems. This has been especially noteworthy in the case of the Pennsylvania Railroad at Philadelphia, and the New York Central, New York, New Haven & Hartford, Long Island and New York, Westchester & Boston railroads in the vicinity of New York. Where both local and through service are operated electrically, however, the problem as to the relative amount of traffic to be handled by electric locomotives and by multiple unit equipment is somewhat complex, and any decision is necessarily based on local conditions.

In general the advantages of multiple-unit equipment as compared to electric locomotives may be summarized as follows:

The long heavy multiple-unit train accelerates more quickly than a train of the same weight hauled by a locomotive. Where stops are frequent a material increase in scheduled speed is thus possible.

In a multiple-unit train the motor equipment is varied to correspond to length of the train, and thus is often more efficiently used than is the case with the electric locomotive, which being of a fixed and definite size cannot be so easily adapted to varying requirements.

The reliability of operation of multiple-unit equipment (several motive power units being employed in a train) is somewhat greater than that of electric locomotive equipment. In the event of a failure on the road, one of the motor cars may often be cut out of service electrically and the train thus enabled to reach the terminal with little or no delay by means of the remaining motors.

The multiple-unit cars, being heated electrically in winter, are free from all difficulty connected with oil-burning steam boilers, and although the cost of power thus used in heating may be considerable, this convenience of operation is valuable. One of the chief sources of expense in maintenance of electric locomotives is the steam heating boiler.

Perhaps the most important advantage of multiple-unit equipment as compared with electric locomotives is in switching, especially in crowded stub-end terminals. Locomotive-drawn trains, after arrival at the terminal must be backed out to free the locomotive. This extra double move is often necessary when the terminal tracks are most congested. The multiple-unit train on the other hand, practically as soon as it has reached the terminal, is ready for the return trip.

There are some limitations, however, to multiple-unit operation as compared with electric locomotives. Multiple-unit cars in general can be operated economically only over tracks equipped with an energized third rail or trolley (although occasionally this type of equipment is hauled outside the electric zone by steam locomotives for short distances). The result is that the cars are not available for duty outside the electrified territory in the event of a local heavy traffic demand elsewhere.

*The equipment furnished by the Westinghouse Electric and Mfg. Co. is described on page 389 of this issue of the *Railway Electrical Engineer*, and that furnished by the General Electric Co. in the issue of July, 1921.

MULTIPLE UNIT TRAINS OF NORTH AMERICA (Heavy Service)

Company No.	Railroad	Key No.	Series No.	No. in service	Year placed in service	System of traction	Contact Conductor: Voltage	Contact Conductor: Type	Wheel diameter (inches)	Weight (lbs.): Total	Trucks without motors	On drivers	Body without equipment	Equipment
1	Boston Elevated Ry. Co.	1-a	01-0150	140	1900	D. C.	600	Third rail	M-34, T-31	68,000	20,900	43,000	34,500	12,600
		1-b	0151-74	24	1903	D. C.	600	Third rail	"	68,000	20,930	43,200	34,570	12,500
		1-c	0175-219	45	1906	D. C.	600	Third rail	"	66,628	19,500	39,900	34,628	12,500
		1-d	0220-0239	20	1911	D. C.	600	Third rail	"	65,600	19,500	40,000	34,500	12,600
		1-e	0240-0294	55	1913	D. C.	600	Third rail	"	66,600	19,500	40,000	34,500	12,600
		1-f	0295-336	40	1917	D. C.	600	Third rail	"	66,383	18,700	38,200	35,183	12,500
		1-g	0500-0635	49	1911	D. C.	600	Third rail	"	86,000	22,000	46,000	48,000	16,000
		1-h	0640-59	20	1912-13	D. C.	600	Third rail	"	86,400	21,950	45,300	48,050	16,200
		1-i	0660-0694	35	1918	D. C.	600	Third rail	"	86,000	22,500	46,000	48,500	15,000
2	Brooklyn Rapid Transit Co.	2-a	.....	550	1902 & later.	D. C.	600	Third rail	.....	.....	.....	.....	.....	.....
		2-b	.....	100	1902 & later.	D. C.	600	Third rail	.....	.....	.....	.....	.....	.....
		2-c	2000-2899	900	1914 to 1921.	D. C.	600	Third rail	34	90,600	22,560	57,300	52,640	15,800
3	Canadian Nat'l Rys. (Mt. Royal)	3	.....	8	1921	D. C.	2,400	Catenary	36	120,000	30,000	120,000	51,000	39,000
4	Chicago Elevated Ry. Co.	4-a	.....	26	1904	D. C.	600	Third rail	34	69,500	22,000	41,000	31,000	13,500
		4-b	.....	150	1905	D. C.	600	Third rail	34	59,500	19,900	35,600	26,000	13,600
		4-c	.....	105	.....	D. C.	600	Third rail	34	.....	.....	.....	.....	.....
		4-d	.....	40	1914	D. C.	600	Third rail	34	68,500	20,900	41,000	37,500	11,100
		4-e	.....	19	1914	D. C.	600	Third rail	34	70,000	19,900	42,000	35,500	14,600
5	Chicago, North Shore & Milwaukee R. R.	5-a	.....	6	1904	D. C.	600	Dir. Susp.	36	67,000	18,000	67,000	32,000	17,000
		5-b	.....	34	1906-10	D. C.	600	Dir. Susp.	36	76,000	18,000	76,000	40,000	18,000
		5-c	.....	45	1915-21	D. C.	600	Dir. Susp.	36	93,000 100,000	32,000	93,000 100,000	12,000 49,000	19,000
		5-d	.....	45	1915-21	D. C.	600	Dir. Susp.	36	93,000 100,000	32,000	93,000 100,000	42,000 49,000	19,000
6	Erie R. R. Co.	6-a	.....	8	1907-12	A. C.	11,000	Catenary	36	98,000	.....	98,000	.....	38,000
		6-b	.....	.....	.....	.....	.....	.....	.....	117,000	23,000	117,000	49,000	13,000
7	Hudson & Manhattan R. R.	7-a	Class A	50	1907	D. C.	600	Third rail	M-34½, T-30	74,550	23,750	47,000	35,170	15,630
		7-b	Class B	90	1909	D. C.	600	Third rail	"	69,620	21,890	43,800	32,100	15,630
		7-c	Class C	50	1910	D. C.	600	Third rail	"	69,620	21,890	43,500	32,100	15,630
		7-d	Class D	96	1911	D. C.	600	Third rail	M-36, T-33	73,000	23,900	46,000	33,100	16,000
		7-e	Class E	25	1921	D. C.	600	Third rail	M-34½, T-30	73,500	24,346	46,200	37,054	12,100
8	Interborough Rapid Transit Co.	8-b	.....	272	1904	D. C.	600	Third rail	M-34½, T-31½	85,500	23,900	51,000	47,000	14,600
		8-j	.....	88	1910	D. C.	600	Third rail	"	59,200	17,700	36,000	26,000	14,600
		8-k	.....	60	1910	D. C.	600	Third rail	"	59,200	17,700	36,000	26,000	14,600
		8-l	.....	6	1915	D. C.	600	Third rail	"	73,000	23,000	46,000	39,800	10,200
		8-m	.....	320	1915	D. C.	600	Third rail	"	73,800	19,200	39,800	43,100	11,500
		8-v	.....	169	1917	D. C.	600	Third rail	"	75,500	23,000	45,000	39,000	13,500
		8-a	.....	828	1902-3	D. C.	600	Third rail	"	55,120	20,010	34,530	24,030	11,000
		8-c	.....	200	1904	D. C.	600	Third rail	"	58,500	16,300	35,000	27,700	14,500
		8-d	.....	272	1904	D. C.	600	Third rail	"	85,460	23,920	51,000	47,040	14,500
		8-e	.....	91	1907	D. C.	600	Third rail	"	59,160	23,920	35,700	21,750	13,500
		8-f	.....	40	1907	D. C.	600	Third rail	"	83,200	25,100	49,869	44,600	13,500
		8-g	.....	190	1909	D. C.	600	Third rail	"	83,200	25,100	49,869	44,600	13,500
		8-n	.....	88	1910	D. C.	600	Third rail	"	59,160	17,700	36,000	26,960	14,500
		8-i	.....	60	1910	D. C.	600	Third rail	"	59,160	17,700	36,000	26,960	14,500
		8-n	.....	6	1915	D. C.	600	Third rail	"	70,960	27,080	45,000	33,100	10,180
		8-o	.....	6	1915	D. C.	600	Third rail	"	73,000	23,000	40,000	39,820	10,180
		8-p	.....	161	1915	D. C.	600	Third rail	"	75,000	27,000	45,000	37,500	10,500
		8-q	.....	320	1915	D. C.	600	Third rail	"	73,788	19,200	39,780	43,088	11,500
		8-r	.....	103	1915	D. C.	600	Third rail	"	75,500	27,000	45,000	35,000	13,500
		8-s	.....	71	1915	D. C.	600	Third rail	"	71,000	33,000	40,740	27,500	10,500
		8-t	.....	108	1917	D. C.	600	Third rail	"	75,500	33,000	45,250	29,000	13,500
		8-u	.....	169	1917	D. C.	600	Third rail	"	75,500	33,000	45,250	29,000	13,500
9	Long Island R. R. Co.	9-a	.....	135	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
		9-b	.....	300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	Metropolitan West Side Elevated Ry. (Chicago & Oak Park.)	10-a	.....	14	1904	D. C.	600	Third rail	34	65,000	16,000	38,600	37,000	12,000
		10-b	.....	77	1904	D. C.	600	Third rail	34	55,000 to 70,000	22,000	38,500 to 41,000	26,600 to 31,600	16,400
		10-c	.....	26	1904	D. C.	600	Third rail	34	69,500	22,000	41,000	31,000	.....
		10-d	.....	61	1914-15	D. C.	600	Third rail	34	70,900	19,900	42,000	35,440	14,600
11	New York Central R. R.	11-a	4100-123	122	1907	D. C.	600	Third rail	M-36, T-33	107,500	25,150	61,350	63,650	18,700
		11-b	4124	1	1907	D. C.	600	Third rail	"	112,100	25,150	63,650	68,250	18,700
		11-c	4155-72	18	1907	D. C.	600	Third rail	"	119,000	26,300	65,200	74,000	18,700
		11-d	4173	1	1907	D. C.	600	Third rail	"	112,300	26,300	61,850	67,300	18,700
		11-e	4125-54	30	1907	D. C.	600	Third rail	"	114,000	26,300	61,300	69,000	18,700
		11-i	4174-92	19	1913	D. C.	600	Third rail	"	117,500	26,350	65,700	72,150	18,700
		11-f	4350-55	6	1907-10	D. C.	600	Third rail	"	113,500	25,150	63,000	69,650	18,700
		11-j	4356-61	6	1913	D. C.	600	Third rail	"	116,000	26,300	65,800	71,000	18,700
		11-k	4193-204	12	1917	D. C.	600	Third rail	"	132,200	33,650	73,100	82,850	15,700
		11-l	4205-37	33	1918-21	D. C.	600	Third rail	"	129,000	33,800	71,600	79,500	15,700
		11-g	4394-97	4	1910	D. C.	600	Third rail	"	119,400	25,150	67,200	75,550	18,700
		11-h	4308-93	2	1910-18	D. C.	600	Third rail	"	118,700	26,000	65,150	74,000	18,700
12	New York, New Haven & Hartford	12-d	4010	1	1914	*A. C.	11,000	Catenary	36	156,500	37,700	156,500	86,687	14,000
		12-b	4011	1	1911	*A. C.	11,000	Catenary	36	139,700	23,013	13,970	60,087	36,600
		12-a	4020-23	4	1909	D. C.-A. C.	600-11,000	Third rail and Cat.	42	173,500	41,000	173,500	65,700	29,800
		12-c	4024-27	4	1912	"	"	"	42	171,100	40,500	171,100	69,000	31,600
		12-e	4028-40	13	1914	"	"	"	42	176,000	40,500	176,000	69,000	36,500
		12-f	4060-61	2	1915	*A. C.	11,000	Catenary	42	169,000	40,500	169,000	68,500	30,000
		12-g	4062-63	2	1916	*A. C.	11,000	"	42	170,000	40,440	170,000	68,500	31,160
		12-h	.....	6	1921	A. C.-D. C.	600-11,000	Third rail & Cat'ry.	42	176,000	40,500	176,000	69,000	36,500
		12-i	.....	2	1921	"	"	"	42	176,000	40,500	176,000	69,000	36,500
13	New York, Westchester & Boston	13	101-140	40	1911 & 1917	A. C.	11,000	Catenary	M-42, T-36	120,000	29,200	71,570	.....	.....
14	New York Municipal Ry.	14	.....	900	1914-20	D. C.	600	Third rail	M-34, T-31	90,600	22,560	57,300	52,640	15,800
15	Northwestern Elevated R. R.	15-a	.....	192	1900-06	D. C.	600	Third rail	34	55,000 to 60,000	18,300 to 20,950	39,000 to 41,000	30,200 to 31,550	16,500
		15-b	.....	20	1908	D. C.	600	Third rail	34	69,000	20,950	41,000	31,550	16,500
		15-c	.....	20	1914	D. C.	600	Third rail	34	68,500	20,950	41,000	37,500	.....
		15-d	.....	43	1914-15	D. C.	600	Third rail	34	70,000	19,960	42,000	35,440	14,600
		15-e	.....	19	1914-15	D. C.	600	Third rail	34	70,000	19,950	42,000	35,440	.....
16	Pennsylvania R. R. (New York)	16-a	201-206	6	1910	D. C.	600	Third rail	38	110,350	26,000	63,550	60,000	24,350
		16-b	4513-14	2	1910	D. C.	600	Third rail	38	108,350	26,000	62,300	58,000	22,350
	Pennsylvania R. R. (Philadelphia)	16-c	501-82	82	1915	A. C.	11,000	Catenary	.....	118,600	31,800	70,600	60,000	26,800
		16-d	4548-51, 4553-57	9	1915	A. C.	11,000	Catenary	.....	116,600	31,800	70,600	58,000	26,800
		16-e	5296-07	2	1915	A. C.	11,000	Catenary	.....	121,600	31,800	70,100	63,000	26,800
		16-f	584-603	20	1917	A. C.	11,000	Catenary	.....	118,600	31,800	70,600	60,000	26,800
		16-g	5909-70	2	1917	A. C.	11,000	Catenary	.....	113,600	31,800	68,100	55,000	26,800
17	Philadelphia Rapid Transit Co.	17-a	.....	40	1906	D. C.	600	Third rail	34	71,000	23,000	46,200	34,150	13,850
		17-b	.....	40	1907	D. C.	600	Third rail	34	76,000	28,500	49,400	33,650	13,850
		17-c	.....	16	1909	D. C.	600	Third rail	34	72,000	23,000	46,800	35,150	13,850
		17-d	.....	4	1909	D. C.	600	Third rail	34	76,000	28,500	49,400	33,650	13,850
		17-e	.....	65	1911	D. C.	600	Third rail	34	70,500	23,000	45,800	33,650	13,850
		17-f	.....	50	1913	D. C.	600	Third rail	34	70,000	23,000	45,500	34,300	12,100
		17-g	.....	50	1921	D. C.	600	Third rail	33	72,500	.....	.....	.....	.....
18	Southern Pacific Co. (O. A. & B. Div.)	18	.....	81	1911	D. C.	1,200	Catenary	36	109,400	24,280	109,400	61,520	23,600
19	South Side Elevated R. R.	18-a	.....	149	1897	D. C.	600	Third rail	34	114,000	.....	114,000	66,120	.....
		19-b	.....	70	1900-3	D. C.	600	Third rail	34	52,714	15,300	31,500	27,000	10,400
		19-c	.....	150	1905	D. C.	600	Third rail	34	55,000	17,500	32,900	24,600	12,900
		19-d	.....	61	1914-15	D. C.	600	Third rail	34	59,500	19,900	35,600	.....	.....
20	West Jersey & Sea Shore R. R.	20-a	6701-62	60	1906	D. C.	675	Third rail, Dir. Susp.	M-36, T-33 "	70,000 80,000	19,950 25,045	42,000 52,800	35,440 46,405	14,600 16,550
		20-d	6763-79	17	1907	D. C.	675	"	"	94,700	25,900	56,200	52,250	16,550
		20-e	5135-36	2	1907	D. C.	675	"	"	94,000	25,900	55,900	51,550	16,550
		20-g	6780-92	13	1912	D. C.	675	"	36	105,000	29,100	61,400	60,000	16,900
		20-h	5137-38	2	1912	D. C.	675	"	36	104,000	29,100	61,400	58,000	16,900
		20-b	5455-7-8	3	1906	D. C.	675	"	M-36, T-33 "	88,000	25,045	52,800	46,405	16,550
		20-c	6421-26 6439-41	9	1906-9	D. C.	675	"	"	92,000	25,900	54,875	49,550	16,550
		20-f *	6427	1	1911	D. C.	675	"	36	101,000	29,100	71,000	55,000	16,900

* Single P. H.

The mileage of multiple-unit motor equipment is often less than that of an equivalent electric locomotive, on account of traffic limitations. The multiple-unit motive power cannot be interchanged between local and through trains. This means that owing to the limitations of traffic, especially in the case of the so-called "fleet movement" of commuter's trains (heavy traffic in the morning and evening with little mid-day travel) much of the multiple-unit equipment can make but one round trip a day. The electric locomotive, on the other hand, which is available for hauling either local or through trains may be more intensively and thus more economically operated in this respect.

The maintenance, reduced to a seat mile basis, is usually higher with multiple-unit equipment than in the case of electric locomotives and standard trailer coaches.

The decision between multiple-unit and locomotive equipment in each individual case is governed by local considerations. The excess cost of multiple-unit car maintenance is often offset by the saving made possible in terminal tracks, on account of elimination of switching requirements. In general, it may be said that each type of equipment has its definite place in the heavy traction field.

In designing multiple-unit equipment there is some question as to the relative advantages of trains made up of all motor cars as compared with motor cars and trailers. This question involves careful study of equipment as well as terminal characteristics. One railroad which started electric operation with mixed motor car and trailer trains has since equipped all cars with motors, while another railroad which started operations with all motor cars has revised the initial policy by acquiring trailers.

Charts, Table and Bibliography

The chart showing the growth of steam railroad mileage electrified and electric locomotive tonnage in heavy traction service in the United States and Canada indicated that track mileage and locomotive tonnage has increased at approximately a constant rate from 1905 to the present time, and that now there is something more than 2,600 miles of track electrified and over 52,000 tons of locomotives in service in the United States and Canada.

Discussion

The greater part of the discussion was offered in the form of a short paper, presented by H. H. Norris, managing editor, Electric Railway Journal, suggesting how an American committee on electrification might be formed, and expressing the need of such a body as follows:

"In opening the report this year with a synopsis of the electrification activities of the committees of the several national societies concerned with heavy traction, the committee has taken one step towards the formation of an American Committee on Electrification. The compilation shows that there is much duplication of effort among the committees, which could be avoided through the functioning of such a joint committee. Such a national committee could act as a clearing house for all information on this subject. On one hand it could suggest topics appropriate for consideration by the several special committees, and on the other hand could collect on its own account the data which would be of general interest. The value of a central, co-operative and unbiased agency of this kind would be very great.

"If and when resolutions are in order, the following might appropriately be passed:

'Resolved, that the executive committee be requested to issue to the proper executive bodies of the American Railway Engineering Association, the American Railway Association Mechanical Section, the National Electric Light Association, the American Institute of Electrical Engineers, the Association of Railway Electrical Engineers and such other organizations as the executive committee may deem expedient, a suggestion that they appoint each two representatives on an American Committee on Electrification, with a view to co-ordinating the activities of these several associations in collecting data regarding heavy traction, and in other ways promoting the study of the subject.'

"As an example of the kind of thing such a co-operative committee could do nothing would serve better than the elaborate bibliography which the committee has been able to present this year in collaboration with the Association of Railway Electrical Engineers. Here is illustrated co-operation on a limited scale. A joint committee could maintain such a bibliography continuously. This bibliography furnishes an excellent start. It will stand some editing and condensation. Having printed this year the complete list, the association might later provide a condensed list of the most important articles, including a brief summary of the salient features of each. This could be made to include articles published up to the date of the completion of the list. The danger of unconscious padding in a list of this sort lies in the fact that an important electrification is reported by the leading domestic and foreign papers in all degrees of completeness and balance. The best one or two of these would suffice, although mention could be made in small type of a few other articles on the same subject for the benefit of those who might not have access to the papers mentioned first.

"It is to be hoped that this bibliography will be used in such a way as to justify the considerable expense and effort involved in compiling and publishing it. It might be well to reprint it in pamphlet form for miscellaneous distribution. A nominal price could be put upon the pamphlet and the association could advertise it along with other prints, so that its existence would not be forgotten.

"The compilation of the locomotive and multiple-unit car data, which the committee was able to get up with the co-operation of the two large manufacturers of heavy traction equipment, is one of the outstanding features of the committee's report and of the year's work. Particularly noteworthy is the table of multiple-unit car data. The admixture therein of data regarding heavy multiple-unit car practice on steam roads, interurban lines and rapid-transit urban lines, together with the general similarity of these data, indicates the substantial similarity of short-haul, high-speed passenger service under these different auspices. This is, we hope, a prophecy of the time when there will be a greater community of interest between the steam and electric roads in relation to suburban passenger traffic.

"It is unfortunate that the chart presented by the committee shows a zero rate of increase in electrification in 1920, after a steady, although small, rate from 1905 on. This slump merely reflects the financial condition of the steam roads. It will cease when conditions improve. There are electrification projects now developing which

will at least restore the normal rate of increase; for example, the Lackawanna Railroad has been making definite plans for a considerable undertaking. The Illinois Central is, of course, on the eve of an important terminal electrification at Chicago. One of the most heartening announcements was recently made of a $7,000,000 contract for railroad electrification in Chile.

"There has been some question as to the appropriateness of the electrification activity on the part of the American Electric Railway Engineering Association. The basis of this criticism is that the matter is properly one for the steam railroads to consider and push. It is true that no electrification project is possible unless the railroads are convinced of the savings that can thus be effected. At the same time we can well look at this matter from the other side. Electric traction, having demonstrated its success under steam road conditions, is looking for new fields to develop. It is to be expected, therefore, that initiative will be exerted by the electrical manufacturing and operating interests who are looking for new worlds to conquer. The steam railroads will necessarily be somewhat conservative in regard to this matter, partly from financial consideration, partly because they have so much money and talent tied up with their steam equipment. The electrical interests have a 'selling proposition' of magnitude."

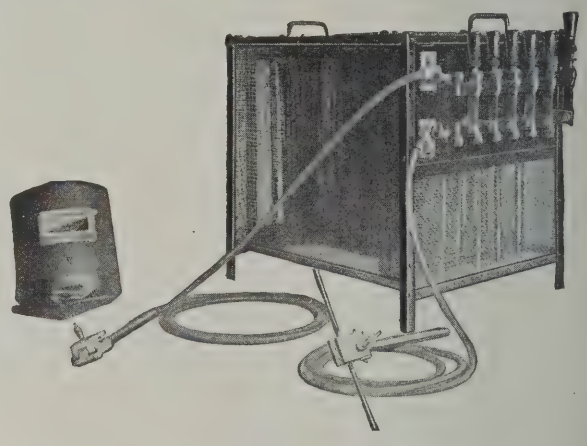
J. H. Davis, electrical engineer, Baltimore & Ohio, called attention to the fact that the diagram accompanying the report indicates that the first electrification work in the United States was started in 1903, while actually it was done in 1895

W. B. Potter, General Electric Company, spoke of the activities in railway electrification in foreign countries and said that many steam railroads in this country were waiting only for more favorable circumstances. Comparative operating expenses of steam and electric traction, he said, have been fairly well established, and he closed his remarks by prophesying that with better financial conditions and the development of super-power zones, electrification will progress rapidly.

An innovation was introduced by L. C. Datz, chairman of the subjects committee, by reading the future plans of the committee at the close of the discussion, so that the members might add suggestions before the plans were presented to the general committee for final approval. The proposed plans for next year, co-operation with the committees on electrification of other associations, a paper on results obtained in South America, continuation of the chart showing growth of electric traction and of the bibliography and the collection of more statistical data including costs and other values on ton-mile, car-mile, and locomotive-mile basis.

Welding Equipment

Welding equipment consisting principally of a portable resistance and the necessary control switches has been placed on the market by the Automatic Electrical Devices Company, Cincinnati, Ohio. Various types of resistances are made for use on direct current circuits of from 50 to



Welding Outfit for 250-Volt Direct Current Circuits

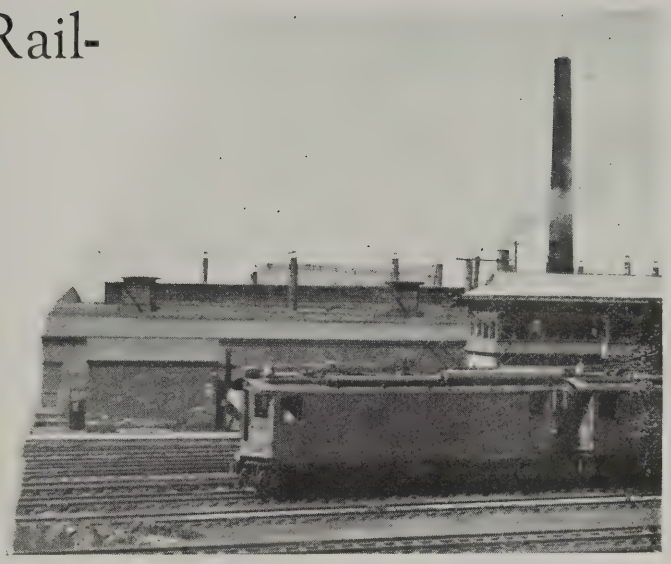
550 volts and the complete outfit includes an electrode holder, a clamp for the power wire, two 10-foot flexible leads and a protective hood for the operator. The complete outfit weighs from 80 to 100 lb., depending upon what voltage they are designed for, and all have a current range of from 15 to 215 amperes. The overall dimensions of the adjustable resistance are 20 in. x 24 in. x 22 in.

Photo by courtesy of the Mississippi Warrior Service

One of the New Developments in Inland Waterway Transport

Standards Applicable to Railroad Electrification

Power Should Be Developed at 25 Cycles and Use of Both Alternating and Direct Current on Trolley Continued



IN an effort to establish standards for electric traction equipment, the Electrification of Railways Advisory Committee in England appealed to George Gibbs, chief engineer of electric traction, Long Island, for an expression of opinion. The recommendations by the committee that power should be developed as three-phase alternating-current at the frequency which is in general use in the district and that 1,500 volts direct-current be used as a standard trolley voltage have given rise to much comment. Mr. Gibbs' letter was subsequently published in the Engineer, London, substantially as follows:

The Question of System

I am not of opinion that at the present time one system of traction at a suitable pressure should be applied as a standard to meet all requirements of railway traffic. Admitting the advantages of standardization in general, yet I believe the establishment of any one system of electrification as standard for British railways would be a mistake at the present time, because:

(1) It is too early in the state of the art to determine and fix the features of any system to the extent required for the purposes of complete standardization, and yet not restrict the future and desirable development of the system selected.

(2) There does not exist sufficient and comparable operating data from which to conclude as to the relative advantages and disadvantages for the future of the two radically different systems most prominently before the railways today, *i. e.*, the "direct-current" and the "alternating-current." Both systems are workable and in use; each has its advocate in important manufacturing interests, and able professional men differ as to which system should prevail. This competition of diverse minds in the development of these different systems is an important factor in ensuring the future determination of the best system; it should not be discouraged by the premature exclusion of either system from trial in the present development period.

(3) Neither system, as now developed and applied to a typical general case, differs greatly in first operating and upkeep costs; therefore, railways will not be greatly penalized except by hampering interchange, by being allowed to work out for the time being the full possibilities of the different systems.

Per contra, I am in favor of certain exclusions and the fixing of certain general requirements of any permitted traction system: thus—

(1) I recommend standardizing the location and clearances of third rail and overhead working conductors. Standards for these have been established for American railways by the American Railway Association. The figures will, of course, differ for British railways. Standardization of this kind will permit the continued development of both the alternating-current and direct-current systems of traction and will ensure interchangeability of running requirements between roads using the same character of traction system.

(2) Standardization suitable and safe limits for voltages in each of the two types of working conductors. These should be as follows:

For third rail 600 volts (nominal) direct-current is recommended. A higher voltage than the above is, in my opinion, inadvisable for general railway usage, because employees or others who have access to the right-of-way cannot be effectively safeguarded from accidental contact with it. Contact with voltages of 1,200 to 1,500 is generally fatal to human life.

The recommended voltage for overhead conductors is 11,000 for the alternating-current system and 3,000 for the direct-current.

In the case of the alternating-current system the maximum is determined by the practical limit in maintaining insulation; 11,000 volts (nominal) is below this point, but experience indicates it is high enough for the heaviest kind of traction and is suitable for any class. A collector system carrying it can be installed and maintained properly and economically within close permanent way and rolling equipment clearances. It should be noted, however, that in an overhead wire system such as the three-phase, which requires two contact wires, insulated from each other and from earth, and two current collectors of different polarity, the practical voltage limit is considerably lower than 11,000.

In case of a direct-current system maximum voltage is limited by other considerations than that of insulation of the working conductor. The demands of economy in distribution and the problem of successful collection of current for heavy trains suggest the highest possible voltage; on the other hand, the limitations in respect of its utilization in the train control and motors point to the desirability of low working voltage. For the general case I am of the opinion that 3,000 volts is the minimum requirement from the standpoint of economy and successful current collection, and is the present maximum allowable for the other considerations.

Frequency

Current frequency should be standardized for traction systems in accordance with the requirements of such purpose and not by a compromise with the conflicting re-

quirements of another service. A frequency of 25 cycles per second is the best for both systems of traction recommended for trial, and should, therefore, be made the standard for traction generating plants.

Power Generation

High-pressure three-phase generation is suitable for both alternating-current and direct-current traction systems, and may be made standard.

The voltage at the generating plant may properly depend upon the local situation; it is quite immaterial for standardization purposes what this actually is, as the voltage is transformed for secondary distribution, and various primary voltages may be utilized in the traction installation of one railway.

A consideration of "frequency" is highly important and no standard should be proposed which will exclude, materially complicate, or hamper the development of either of the two systems suggested.

One of the features making for simplification in the single-phase alternating-current system is that current from the generating plant is used in the working conductors without change, except, if desirable, by altering the voltage in a transformer. It is essential, however, that the "frequency" employed in the working conductors shall not exceed 25 cycles per second. If a higher generating frequency than the above is standardized it would complicate the alternating-current system; thus to utilize 50 cycles it would be necessary either to employ "frequency changers" or to install in the central station separate 25-cycle generators for railway purposes. The latter plan is employed to some extent in America, and it is found practicable for electric supply companies to install in the same station high-frequency generators for commercial purposes and 25-cycle generators for railway work and provide one or two large motor units for interchange of power between the two parts of the station.

With the direct-current system which employs alternating-current generation and transformation and conversion in sub-stations any desired frequency from 25 to 50 (or more) cycles may be used. Twenty-five cycles is, however, not only a suitable standard for the direct current, but is from some considerations better than a higher frequency. Therefore:

(1) Three-phase, 25-cycle generation at any desired voltage or voltages should be specified as a requirement to allow the flexible development of electric traction systems.

(2) Commercial power plants, which employ other frequencies, may be utilized for railway power purposes either directly in case of direct-current traction or by the installation of separate generators and motor generator tie-in sets, or frequency changers in the case of the alternating-current traction.

Costs

The investigation of the Chicago Association of Commerce is probably the best source of information which has appeared to date regarding the details of first and operating costs of electric systems. This report was completed in 1915. It covers a minute investigation of a great railway problem within a compact area of 428 square miles in and around a very large city. Within this area thirty-nine different railway companies operate dense passenger, freight and switching services over a network of tracks comprising an aggregate mileage of 4,500. The net first cost of the equipment required to operate this entire system electrically was estimated and analyzed with great care for three different systems and gave the following results: Direct current, 600 volts, third rail, $188,132,314; direct current, 2,400 volts, overhead, $181,891,122; single-phase alternating current, 11,000 volts, overhead, $178,127,230. In other words the first cost was substantially the same for all three systems. This conclusion is, of course, for short-haul conditions; for long-distance haulage the showing for the high-tension system, as compared with the third rail, would be better. For average conditions estimates I have made on important projects indicate a first cost difference of 15 to 20 per cent in favor of the high-tension overhead alternating-current or direct-current trolley systems as compared with the direct-current third rail, and of the two high-tension systems the alternating current appears in every case to cost less than direct current.

As to operating costs, the Chicago report showed for items affected, a substantial saving per train mile as compared with steam. The saving was least in case of the 600-volt third-rail system and greatest for the 11,000-volt alternating-current system, but there was not a very great difference between the latter and the 2,400-volt "overhead" system. The conditions, however, in the Chicago district are somewhat peculiar; for the average railway condition, estimates indicate differences of 10 to 16 per cent in favor of the high-tension trolley systems as compared with the 600-volt direct-current third rail and the high-tension alternating current appears in every case to be more economical than the high-tension direct current.

Factors Affecting the Selection of a System

The important considerations governing the selection of a system are:

(1) Adaptability to all physical conditions of the railways.

(2) Economy in first and operating costs.

(3) Flexibility as regards conducting varying kinds and volumes of traffic.

(4) Suitability for extension.

(5) Possibilities as regards future advance in the art and improvements in details.

I would work, as far as consistent with the above, towards the elimination of systems which are applicable to special cases only. This, as before indicated, would narrow the selection to the adoption of one of the high-tension overhead conductor systems.

The 600-volt third-rail direct-current system would only be considered for extensions to existing installations or for very special cases.

The 1,500-volt direct-current system could only be adopted with an overhead conductor and for light traffic requirements; 1,500-volt third rail cannot be used generally because of its danger to life. The 1,500-volt system is an interim development only. Higher voltage direct-current systems, such as the 3,000-volt system, have promise for the future and their development should be allowed to continue unhampered.

The 11,000-volt alternating-current system likewise has a broad field of usefulness and promises well for future development.

The selection, therefore, of a proper system for general use appears to lie between the 3,000-volt direct current

and the 11,000-volt alternating current. I have referred to the existing difference of opinion as to these two systems, and since I am not recommending the elimination of either from adoption at present, it is unnecessary for me to indicate my preference. I should approach any concrete problem upon its merits along the lines laid down, having regard to the latest experience and facts as to the state of the art at the time when decision is to be made.

Report of French Commission Not Well Founded

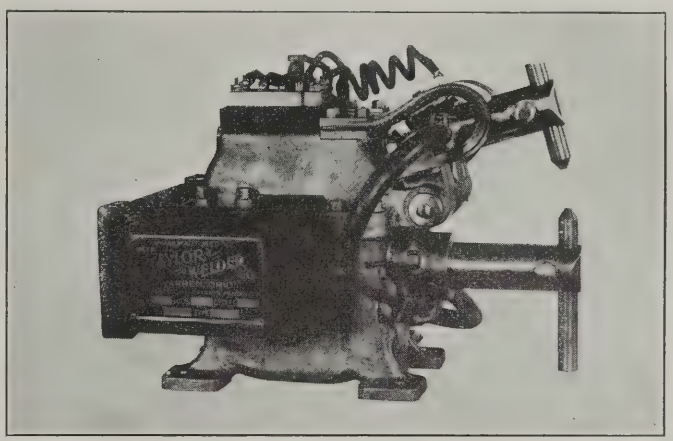
I have looked through the voluminous report of the French Commission on Electric Traction, and, frankly, its conclusions do not seem to be well founded on the data presented. Perhaps the commission has arrived at a correct conclusion, having regard to the particular conditions in France, but the reasons given for condemning the single-phase system seem inadequate and largely the results of a "scare" as regards the inductive interference question. The commission seems to have been dominated by telephone and telegraph experts. It also seems to have been greatly influenced by reports of the high cost of maintenance of the alternating current, which, they state, is at least double that of direct current, a conclusion which is absurd. No effort seems to have been made to equate operating conditions in comparing systems, and I doubt if the commission really had any accurate figures of cost of maintenance of the alternating current. It does not seem to have attached much importance to the future trend of development and possibilities in connection with both alternating-current and direct-current traction.

English Report Disappointing

I was interested, and disappointed, in reading the Interim Report of the Advisory Committee on Electrification of Railways. It would be valuable to know what reasons led the committee to the adoption of the 1,500-volt direct-current as standard. I think a mistake has been made, even if it should prove to be the eventual system, because the adoption of any standard now is going to put the development of electric traction in a straight jacket. The development of both the alternating-current and the direct-current systems should continue in order to get the best results finally from electrification.

Bench Type Spot Welder

A new spot welding machine of the bench type, having a capacity of two pieces of No. 30 to No. 16 gage sheet metal, has recently been put on the market by the Taylor Welder Company of Warren, Ohio. The machine has a cast copper frame which acts as a secondary and adds to its efficiency. Two horns of cold drawn copper 1¼ in. in diameter protrude from the machine, the upper horn being capable of movement through a distance of one inch. The lower horn is made adjustable by drilling three sets of holes in the base of the frame and setting the horn to suit the work, a long electrode being



Bench Spot Welder with Water Cooled Welding Horns

furnished to meet this condition. With the lower horn in its highest position the distance between the two horns is three inches. This distance can be increased to five inches when the lower horn is in its lowest position. The transformer has a capacity of 3 kw. and a 4-step regulator is used for adjusting the current. Cooling is effected by the circulation of water through both the upper and lower horns. The floor space occupied by the machine is 10 in. by 17 in. and the extreme height from the bench is 12 in. An automatic single pole switch closes the circuit, and the upper horn and contact point is brought against the work by the operation of a foot pedal, not shown in the illustration. The approximate weight of the machine is 150 lbs.

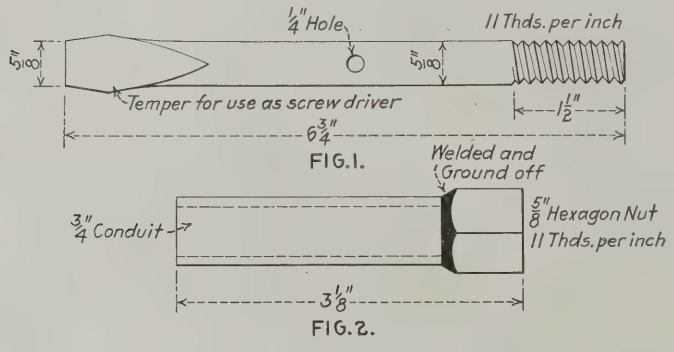
South End of the Cedar Hill Yards of the New Haven

Tool for Pole Shoe Bolt

By E. R. Chinberg,
Electrical Foreman, Chicago, Rock Island & Pacific Railroad.

To the many car lighting electricians who have skinned their knuckles and "cussed" and had hard work in general while trying to remove the pole shoe bolt in a 2.6 kw. car lighting generator, I wish to describe a tool, the use of which eliminates the necessity and cause of the "cussing" and hard luck.

The nuts on these bolts are usually very hard to remove on account of the rusting and corrosion on the bolt and nut, and on account of the bolt having a flat head countersunk into the pole shoe it is not possible to



Details of Construction

hold them with a wrench. As the heads are slotted usually, a chisel is ground to the shape of a large screw driver and held with a small pipe wrench, after which the nuts are screwed off or on as desired. This process is usually accompanied by hard luck, however, and a great deal of time is unnecessarily consumed.

In using the pole shoe bolt clamp, the sleeve should be backed off until it is against the head of the opposite bolt —the countersinking in the pole shoe will keep the clamp from slipping. The more difficult it is to remove the nut, the more the sleeve will unscrew and the tighter the bolt will be held, due to the action of the right-hand threaded sleeve. For particularly obstinate bolts, a ¼-in. hole is provided in the shank of the screw driver so that a small rod can be used to assist in holding the pole shoe bolt. In applying the nut, the clamp has to be tightened up with a wrench.

Fig. 1. shows the dimensions in detail for making the screw driver which should be made from soft steel and tempered the same as for screw driver service. Fig. 2 shows the details of the sleeve which is merely a ⅝ hexagon nut, welded to a piece of ¾-in. conduit and ground off smooth.

How "Hard Times" Start

Across the editorial desk from some unremembered source came a little bit of French allegory.

A portrait painter sat in his favorite cafe sipping his wine. His first small bottle finished, he was about to order more, when his eye fell on a headline in the *Figaro,* "Hard Times Are Coming," so instead of ordering his usual second bottle he called for his check.

"Is there anything wrong with the wine?" asked the landlord.

"The wine is good, but I did not order a second bottle because hard times are coming, and we must economize," explained the artist.

"Hard times," said the landlord. "Then my wife must not order the silk dress we planned, but must take one of cotton."

"Hard times," repeated the dressmaker when the order was canceled. "This is no time to expand. I must not make the improvements I had planned in the place."

"Hard times, eh?" said the builder when the dressmaker canceled the building plans. "Then I cannot have my wife's portrait painted."

So he wrote to the artist and canceled his order.

After receiving the letter the artist went again to his favorite cafe and ordered a small bottle of wine to soothe him. On a nearby chair was the paper in which he had read of hard times two days before. He picked it up to read more closely, and found it was two years old! —*Kiwani's Magazine.*

Ticket Gamblers

Two men were waiting for a train and one said: "I will ask you a question, and if I cannot answer my own question, I will buy the tickets. Then you ask a question, and if you can not answer your own, you buy the tickets."

The other agreed to this.

"Well," the first man said, "you see those rabbit holes? How do they dig those holes without leaving any dirt around them?"

The other confessed: "I don't know. That's your question, so answer it yourself."

The first man winked and replied: "They begin at the bottom and dig up!"

"But," said the second man, "how do they get at the bottom to begin?"

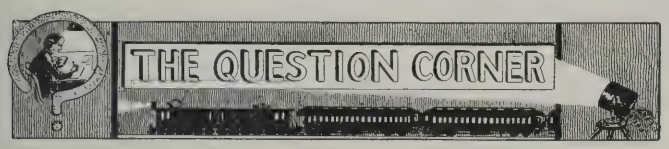
"That's your question," was the first man's rejoiner. "Answer it yourself."

The other man bought the tickets.—*Boston Post.*

Not for Her

An old dame at a railway station asked a porter where she could get her ticket. The man pointed in the direction of the ticket office. "You can get it there," he said, "through the pigeonhole."

"Get away with you, idiot!" she exclaimed. "How can I get through that little hole? I ain't no pigeon!" —*Houston Post.*



Answers to Last Month's Questions

1. Give formula for magnetizing a steel bar, size 6 in. by 1½ in. by ½ in.; state length of wire, size, voltage and current; also the length of time required to magnetize this bar.

2. Give test to determine if the bar is thoroughly magnetized.

3. If a magnet loses its strength, can it be magnetized to its normal strength?—A. H. M.

* * *

1. Steel bar magnets differ considerably from electro-magnets made of soft iron. Soft iron cores, when subjected to sufficient magnetizing force, become saturated with magnetism, that is, a point is reached in their magnetization beyond which no amount of magnetizing force produces any appreciable increase in magnetization. For making permanent magnets, good close-grained rolled steel, that has not been heated, since it was made, is best. The steel is first tempered glass hard by heating it to a moderately bright red temperature and plunging it edgewise into water or oil. The magnetism of the permanent magnet, however, differs from the electro-magnet in that the magnetism in the former resides almost exclusively in the surface of the bar. The process of magnetizing a steel bar after it has been hardened usually consists of placing the bar in a strong magnetic field of a solenoid. A magnetic field of sufficient strength to magnetize to saturation a soft iron bar of the same size will be sufficient to magnetize the steel bar, described, although the permanent magnet will never be as strong magnetically as the electro-magnet. A soft iron bar magnetized to saturation has a flux density of about 110,000 lines of force per square inch. To produce this flux density, a magnetomotive force of 300 ampere turns per inch of length is required. The length of the bar stated in the question is 6 in.; hence, the total magnetizing force should be 300x6, or 1800 ampere turns. It will be seen, therefore, that the voltage and length of wire are not the determining factors. Any product of turns and amperes which will produce 1800 will give the desired results regardless of the voltage of the circuit or the size of the wire. The time required to magnetize the steel bar is very brief, as it is only necessary to place the bar in such a solenoid with the current on, and remove it almost immediately.

2. There is no simple test whereby it can be determined whether or not a steel bar is thoroughly magnetized. About the only guide there is, is to compare the lifting power, or attractive power, of the magnet after it has been placed in a strong magnetic field, with the magnetic strength of the same bar after it has been used and has received more or less jars and knocks.

3. A magnet which has lost its magnetism can be again magnetized to normal strength by placing it in the magnetic field in the same way in which it was magnetized at first.

* * *

Questions for October

1. *I recently had to make a few changes in a call bell system, which at first seemed to be quite difficult. The job was to install two extra bells and pushes. The additional equipment consisted of another bell at station* **A**, *to be operated from a push button at station* **B**, *and a second bell to be situated at station* **B** *to be operated from a push button at station* **A**. *This equipment was in addition to the two buzzers already in operation at the respective stations. Between station* **A** *and station* **B**

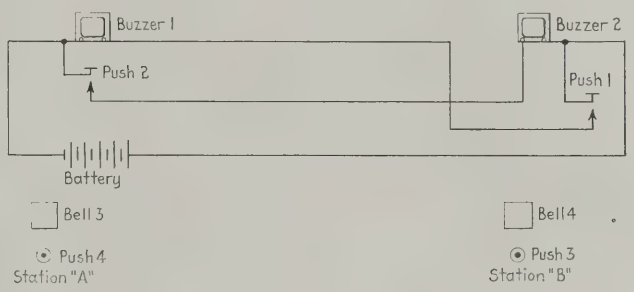


Diagram Referred to in Question No. 1

there was a stretch of 800 feet with several floors of hardwood and concrete and for a distance of 300 feet the wires ran underground. With 50 feet of wire on hand, and no means of obtaining any more, it was required that the job be done in a hurry. I did have, however, plenty of switches and push buttons of various kinds and also plenty of dry cells. I would like to see some of the solu-

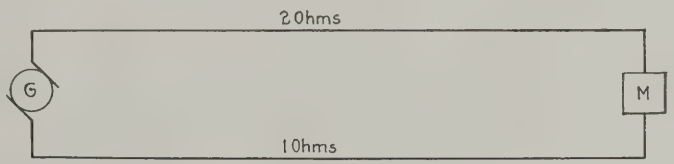


Diagram Referred to in Question No. 2

tions from other readers of the Railway Electrical Engineer. *I believe there are plenty of ways to hook up this little system.—A. H. M.*

2. *I have run across a problem that puzzles me or else there is something missing. I am sending you the problem to get some information and I would like to have you put it in the Question Corner and give an explanation how to work it.*

The generator in the sketch delivers 6 kw. to the line and the motor uses 5.7 kw. It is required to find the (a) watts lost in the line; (b) voltage and current of the motor (c) Brush potential of generator.—C. D. F.

NEW DEVICES

A New Conduit Bender

A new pipe type bending tool, known as the E-Z conduit bender, has been recently placed on the market by the Henderson Electric Company, Ampere, N. J. The bending bosses of this tool are located in such a position as to bend the conduit with the least effort. The thread shown is for a one inch pipe handle which should be about three and one half feet long. The tool may also be used as a stationary bender by resting the end of the handle on the floor at an angle and fastening the bender head to a post or bench with a lag screw or bolt through the hole shown in the illustration. Any bend or combination of bends in half inch conduit may be made with the work in sight at all times. The bending is done in a deep, open groove, the same size as the conduit. The sides of the groove serve to keep the conduit from kinking or flattening and they also grip the conduit as soon as the bending starts which prevents slipping.

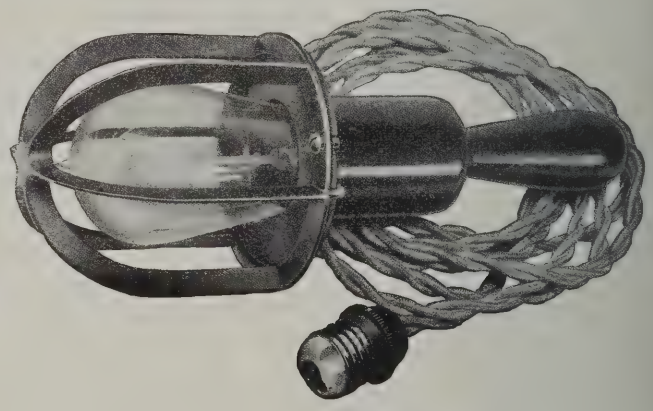
The E-Z Conduit Bender

Used as a hand bender, it will grip and bend a straight or bent conduit. By reversing the bender head, bends already made can be straightened or adjusted.

Portable Lamp with Guard

A new type of portable lamp, which is light, strong and easy to wire, has been placed on the market by Russell & Stoll Company, New York. The casing entirely surrounds the socket and extends along the lamp to a point nearly opposite the base of the filament, thus affording protection for the socket, as well as guarding the lamp, without materially interfering with the sphere of illumination. The casing is flared out to receive the "cage" or guard which is attached by a bayonet joint and locked by a screw which engages with one of the three notches on the flange. The guard is cast of a special aluminum alloy with flat guard strips radiating outward so that the whole construction is exceptionally strong and light.

Another feature of construction is the separable handle which is screwed directly on to the ⅜ in. threaded stem of the socket, the stem passing through a hole in the bottom of casing where the handle is fastened. This makes a simple but substantial joint and at the same time facilitates the wiring up of the socket as there are no long restricted passage through which to thread the wire.


Portable Lamp and Connecting Cord

A New A.-C. Starting Switch

A compact, light weight, quick-acting contactor with blowouts and copper to copper rolling contacts is the outstanding feature of the new across-the-line type of starting switch just being placed on the market by the Allen-Bradley Company, Milwaukee. This starting switch is for use with small alternating current induction motors that can be connected directly to the supply lines. Automatic control of the motor is obtained when the starting switch is used with a push button, pressure gauge, float switch, thermostat or any other type of pilot circuit control.

The principle of this switch is not new, as the company has manufactured across-the-line switches for a number of years, but the design is new and distinctive in the simplicity of the assembly of the switch parts and cabinet. The copper to copper rolling contacts, blowouts and the laminated magnetic circuit are the same design as used on the larger quick acting magnetic switches, but simplification of the assembly make this switch available for general use as a safety device with all automatic features

where formerly the cost made it prohibitive when compared to manual switches.

Complete overload and low voltage protection are offered by the starter when used with the standard push button. Failure of the supply voltage or a continuous overload will open the contactor, thus disconnecting the motor. Return of the voltage will not reconnect the motor unless the start button is pressed. Likewise the motor cannot be started after an overload unless the start button is pressed. When used with float switches or pressure gauges the starters are furnished with hand reset overload relays to prevent restarting of the motor after an overload has opened the circuit. With these auxiliary controls low voltage release is offered. Return of voltage to normal after temporary suspension will automatically re-connect the motor and insure continued performance from the pump, compressor or similar connected equipment.

The use of magnetic blowouts, together with a light

Views of the A. C. Starting Equipment

weight contactor which makes and breaks the circuit quickly, practically insures interruption of the circuit even under extreme conditions of overload.

The overload relays are of the inverse time limit dash pot type. They are the same as used for overload protection on all of the company's starting and current controlling devices and by other manufacturers as part of their standard starting equipment. The relays have a unique double seal of the piston in oil, which insures the full time element, yet there is little motion of the piston until the seal breaks, when the piston is released suddenly so that the relay contacts are tripped open quickly and positively. The relays can be set so that a heavy overload will open the switch quickly, but a lighter, momentary overload will not trip the switch unless it continues for several minutes. The time taken in pulling the piston out of the oil varies inversely with the amount of current flowing in the current coil. This allows for the momentary overloads that might occur in normal service and yet gives full protection against burnouts. The dash pot is removable and both current and time adjustments can be made quickly and accurately. The settings are visible and predetermined.

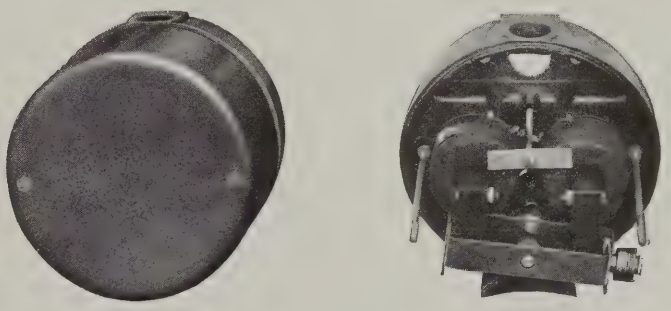
The push button stations for use with this switch are made from standard 3¼ in. octagon outlet conduit fittings with special pressed steel covers. The station can be quickly attached to the conduit.

Electric Arc Welding Machine

A new type of electric arc welding machine designed for welding studs to steel plates has been developed in England by Buckley, Saunders & Company. The welding head of the machine is held in position on the steel plate by two electro magnets and the stud to be welded to the plate is held by a chuck in the welding head. When the welding head has been placed, the throwing of the switch causes an arc to be made and held for a period of a few seconds between the stud and the plate, after which the machine automatically forces the stud against the plate and completes the weld. The welding current can be cut off at the instant that the stud is forced against the plate or can be allowed to flow for any desired predetermined time thereafter.

New Phase Failure and Reverse Protection Relay

A new phase failure and reversal protective relay have recently been brought out by the Cutler-Hammer Manufacturing Company of Milwaukee. The degree of protection which this relay affords is obtained by a frictionless contact which requires practically no torque for positively maintaining the control circuit. It can be



Relay With and Without Cover

readily adjusted to give maximum protection under the voltage conditions existing on any particular installation. The relay is intended to be used on installations of polyphase motors and operate to prevent injury to machinery in case of phase reversal and burning out of the motor in case of phase failure.

One-Hand Drill

The Knight Engineering & Sales Company, Los Angeles, Cal., has placed on the market a light weight electric drill designed for small work. The drill housing is made of aluminum and the pistol grip is carefully designed to fit the hand. As the grip is on a direct line with the chuck a straight line pressure is given to the drill bit, thus eliminating the danger if side strain. A thumb operated switch button controls the power.

General News Section

A contract has been awarded to A. S. Schulman, Chicago, by the Chicago Union Station Company which includes the installation of all of the wiring and switchboard equipment for a substation which will supply power to the new Railway Mail Terminal Building, Chicago.

Excavation work on the second Simplon tunnel in Switzerland, parallel to the first, was completed on September 13, according to cable dispatches from Geneva. The masonry work on the new tunnel is said to be well advanced and it is expected that it will be open for traffic by the first of the year.

The English Electric Company, of Canada, Ltd., a newly formed company associated with the English Electric Company of Great Britain, has acquired control of the Canadian Crocker-Wheeler Company, Ltd. R. A. Stinson, vice-president and general manager of the latter company, has been elected president and general manager of the new company.

The directors of the Argentine Transandine Railway have asked authority to increase the capital of the company from 2,500,000 to 4,000,000 gold pesos, according to Commerce Reports, the additional funds to be used in covering the expense of electrifying the line. Plans are said to be under way providing for the joint operation of the Chilean Transadine with the Argentine Transandine.

The latest reports regarding the proposals for the electrification of certain sections of the government railways of the Union of South Africa are to the effect that no bids have as yet been accepted, and that it is possible that the program may not be carried through at this time to the full extent planned for, according to Commerce Reports. It is reported that business conditions may influence the government to defer this work.

The Western Electric Company is in a strong financial position according to a statement issued recently by Charles G. Du Bois, president. Mr. Du Bois said:

"The Western Electric Company reports sales for the eight months ending August 31 as approximately $122,000,000, or almost the same as for the similar period of 1920.

"Since the beginning of the year the company has reduced its floating debt by $7,500,000, and has increased its cash balance by $6,000,000, an improvement of $13,500,000 in its financial position."

General Electric Company Again Reduces Payroll

Another wage and salary reduction of 10 per cent for all employees has been announced by the General Electric Company, to take effect on October 31. The announcement by E. W. Rice, Jr., president, is as follows: "In accordance with an order of the board of directors a reduction of 10 per cent will be made as of October 31, 1921, in the salaries of all officers and employees of the company."

Several reductions have been made since last January. The first one became effective February 1, when the wages of day workers at the Schenectady plant were reduced 10 per cent and the pay of piece workers 10 per cent. The bonus system was discontinued. Another reduction of from 10 to 30 per cent was announced in July and the size of the working forces have been reduced in accordance with the company's plan of retrenchment.

Direct Current Recommended for Electrification in Netherlands

The commission appointed in January, 1920, to study the desirability of electrification of all railways in Holland has prepared a report which, it is understood, not only favors such a scheme but recommends the use of 1,500 volts direct current, according to the Electrical World. It is also recommended that the electrification be made in connection with the proposed unification of electric light and power service throughout the country. There is no indication, however, that this work will be undertaken in the near future.

Electrification of Railroads in Madagascar

The governor general of Madagascar has decided to electrify the railroads of that colony from Tananarive to Tamatave, according to Commerce Reports. A hydroelectric power station will be built on the Vohitra river to furnish a maximum power of 30,000 horsepower. The length of the line is 93 miles and the total cost of the installations will reach $4,620,000. Assistant Trade Commissioner F. G. Singer, who furnished this information, states that the governor general is also considering the electrification of the future railroad from Diego-Saurez to Joffre Ville, a road about 22 miles in length.

Westinghouse Receives $7,000,000 Railway Contract from Chilean Government

The Westinghouse Electric International Company announces that it has received final confirmation of the contract to supply the equipment to electrify the Chilean State Railroad between Valparaiso and Santiago, and the Los Andes Branch.

This contract, which was received from the Chilean Government through the company's Chilean agent, Errazuriz, Simpson & Co., associated with Spruile Braden of New York, covers the most important railway electrification undertaken since the beginning of the war, and the largest ever undertaken by an American firm outside of the United States.

The main line, which is 116 miles long, is now under steam operation and is the most important railway line in Chile. It connects the leading seaport (Valparaiso) with the capital (Santiago), while the line to Los Andes is 28 miles long and forms the Chilean State Railway section of the trans-continental line to Buenos Aires.

The equipment to be furnished consists of eleven local passenger locomotives, fifteen road freight locomotives, six express locomotives, seven switching engines and five sub-stations of 4,000 kw. capacity each. All of these locomotives are of the Baldwin-Westinghouse manufacture. The 3,000 volt direct current system which will be used will be strictly American in character.

The capacity of this equipment will be 50 percent greater than their present traffic demands, and the plans have been so drawn that an increase of traffic capacity three times the present demands can readily be obtained.

Owing to the abundance of water power in Chile and the high price of fuel all of the Chilean railroads will eventually be electrified, and the present project is the first step in this progress.

The contract, which has a total value of $7,000,000, was secured in keen competition from Germany and other European countries. It represents the third large order for electric railway supplies received by the Westinghouse Electric International Company from foreign countries in the past few months, the others being obtained from France and Japan.

Other American concerns who received contracts for requirements of the Chilean Railroad are the American Locomotive Company, Pressed Steel Car Company and the Anaconda Copper Mining Company.

The Errazuriz, Simpson Co. of Chile will build the overhead construction.

Electrification of Japanese Railways

The official plan for the electrification of the railways of Japan has recently been revised and a new electric bureau established, according to information published in Commerce Reports. According to the plan now being worked out by the Department of Railways, the first steps will be to electrify the entire Tokio line, the traffic of which has been increasing enormously each year, from Tokyo to Kobe, and a part of the Central line between Iidamachi station in Tokyo and Kofu, in the rear of Mount Fuji, where many tunnels make transportation slow. Electric trains will be used exclusively for passengers, freight trains being operated by steam as at present.

Transmission of Electric Power at 1,000,000 Volts

Experiments in the transmission of electrical energy at a potential of 1,000,000 volts were made recently in a laboratory of the General Electric Company at Pittsfield, Mass. The result of the tests indicated that a line having conductors 4 in. in diameter, or larger, would be necessary for the transmission of 1,000,000 volts, but also confirmed the belief of the engineers that it will be commercially feasible to employ higher voltages than any now in use. A power line is now under construction on the Pacific Coast, over which energy will be transmitted at 220,000 volts.

Physical laws applying to high voltage phenomena were found to hold good at these enormous potentials. In the course of the experiments the gap spacings for sphere and needle spark gaps were carefully checked up and prolongation of existing curves (750,000 volts and below) were found correct up to 1,100,000 volts.

Arc over tests were also made on strings of standard ten-inch suspension insulators up to 1,100,000 volts. A short transmission line was tested for corona conditions and the laws of corona were checked at similar potentials and found to hold.

Personals

W. J. Timmins formerly assistant chief of research laboratory, Edison Storage Battery Co., is now construction engineer with Pewick Bros., Des Moines, Iowa.

W. S. Murray, who recently completed his work as chairman of the Superpower Survey conducted by the United States Geological Survey has formed, with Mr. H. Flood, Jr., a consulting engineering firm under the name of Murray & Flood, with offices in the Grand Central Terminal, New York City. Their specialties will be public utility interconnections, power plant engineering and heavy traction railroad and industrial electrifications.

J. H. McMullen has been appointed railroad representative in the Boston, Mass., territory, for the Western Electric Company, succeeding E. R. Morgan and E. B. Denison, formerly in charge of the Minneapolis, Minn., territory, has been appointed Detroit, Mich., railroad representative, succeeding R. S. Cowan.

H. B. Titcomb, vice-president of the Pacific Electric, with headquarters at Los Angeles, Cal., has been elected president of the Southern Pacific of Mexico and the Arizona Eastern, to succeed Epes Randolph, deceased. Mr. Titcomb was born at Indianapolis, Ind., in December, 1871. He graduated from the Cogswell Polytechnical College in 1891, and in July of the same year entered the service of the Southern Pacific as a draftsman. He was promoted to assistant engineer in the construction division in 1898; was appointed roadmaster on the Western division in 1899, and was successively roadmaster on the Shasta and Sacramento divisions from 1900 to 1904. He was assistant resident engineer from 1904 to 1905, resident engineer at San Joaquin, Cal., from 1905 to 1906, and at Los Angeles from 1906 to 1909. He was district engineer, with headquarters at Los Angeles, from 1909 to 1914, and maintenance of way assistant to the assistant chief engineer, with headquarters at San Francisco from 1914 to 1917. In October, 1917, he was promoted to superintendent of the Stockton division, with headquarters at Stockton, Cal., which position he held until September, 1918, when he resigned to become vice-president of the Pacific Electric.

H. B. Titcomb

W. C. Kelly, electrical foreman of the St. Louis division of the Illinois Central, with headquarters at Centralia, Ill., has been transferred to the Central of Georgia in the capacity of chief electrician, with headquarters at

Macon, Ga. Mr. Kelly was born on July 4, 1888, at Harrisburg, Ill., and received his education in the public schools of that place. On September 6, 1906, he entered the employ of the Illinois Central Railway in the road department, where he remained until June, 1908. He was then transferred to the telegraph department and served in the capacity of office wireman until March 10, 1913, when he entered the electrical department as division electrical foreman. On September 1, of this year, he was transferred to the Central of Georgia as noted above. O. E. King, acting division electrical foreman of the Kentucky and Tenessee divisions of the Illinois Central, will succeed Mr. Kelly at Centralia.

R. I. Baird, who was from 1909 to 1917 connected with the sales department of the Electric Storage Battery Company, Philadelphia, Pa., has returned to the service of that company and is now in charge in the western district of sales of Exide batteries for railway car lighting, industrial trucks, etc. Mr. Baird's headquarters will be at the Chicago office of the company, in the Marquette building. The railway signal work is in charge of H. B. Crantford, who formerly was in the service of the Chicago, Milwaukee, & St. Paul. Mr. Baird was educated at the Armour Institute of Technology, Chicago, and has been connected with the Automatic Electric Company and the Bryant Zinc Company. He was also in railroad work, having served in the signal department of the Illinois Central. Since 1917, he has represented the Delco Light Company, in Montana.

R. I. Baird

Obituary

Robert Ten Eyck Lozier, a noted electrical engineer, died in New York City on August 21. He was born at South Norwalk, Conn., in 1868. At the age of 14 he entered the employ of Thomas A. Edison. During his busy career he took out many electrical patents and for the past fifteen years had been a consulting engineer. Mr. Lozier was perhaps best noted for his pioneer work in the development of electrical power. He was a member of the Engineers' Club, a fellow of the American Institute of Electrical Engineers and a life member and past president of the New York Electrical Society. During the war he was in charge of hydroplane construction at the League Island Navy Yard.

David H. Wilson, Jr., consulting engineer of the Erie, died in New York on September 15. Mr. Wilson was born at Paterson, N. J., in 1879, and was educated in the grade schools of Paterson, at the Bliss Electrical School, Washington, D. C., whence he was graduated in 1899, and Purdue University, from which institution he was graduated in 1902. Following his graduation, he was in charge of transmission line and electric railway construction in Porto Rico and subsequently was engaged in a similar connection in Canada. He went with the Erie in 1906 as electrical engineer, which position he held until 1911, when at his own request he was granted a leave of absence to work out a storage battery and an electric welding machine. When the Wilson Welder and Metals Company was organized he was elected vice-president. He re-entered the service of the Erie on June 1, 1921, as consulting engineer, which position he held at the time of his death.

Charles W. Davis, vice-president and general sales manager of the Standard Underground Cable Company, Pittsburgh, Pa., died Sunday, September 11, in the Memorial Hospital, New York. He had been in failing health for several years and had gone to New York for special medical treatment. Mr. Davis was born in Pittsburgh 48 years ago and was educated at the Western University of Pennsylvania, now the University of Pittsburgh, and at Massachusetts Institute of Technology. His connection with the Standard Underground Cable Company began shortly after his graduation from college, or about 1899, at which time he was employed by the company as construction engineer on a large cable installation in Mexico City. Later be became superintendent of construction and manager of the central sales department, continuing in these positions until 1915, when he was elected vice-president in charge of the general sales, construction and accessories departments.

Mr. Davis was well known in the electrical industry as an expert on the design, manufacture and installation of electric cables and accessories, and had contributed largely to the development of the art by his investigations and occasional technical papers, and by his many inventions dealing with improvements in methods of cable construction, installation and operation.

Trade Publications

Safety Motor Starters and safety panel boards of a new type are described in catalog 12-A, issued by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

An attractive 24-page booklet known as Bulletin No. 43, describing locomotive coaling plants and equipment for the handling of railroad coal, sand and cinders has been prepared for distribution by Roberts and Schaefer Company, Wrigley Building, Chicago, Ill. The booklet is 8½ in. by 11 in. in size and is profusely illustrated.

Lighting Data.—The Lighting Service Department of the Edison Lamp Works of the General Electric Company has issued a new series of bulletins on the general subject of electric lighting with titles as follows: Reflectors for Incandescent Lamps; The Lighting of Printing Plants; Lighting for Outdoor Sports; Ship Lighting; Railway System Lighting, Buildings and Yards; Lighting for Indoor Recreations. The numbers of these bulletins are respectively LD123, LD125, LD126, LD127, LD128 and LD129. They are profusely illustrated, contain from 16 to 34 pages each and the information given on each subject is quite complete.

Railway Electrical Engineer

Volume 12 NOVEMBER, 1921 No. 11

Indexes For 1921

In accordance with the usual custom the number of printed indexes for the 1921 volume of the *Railway Electrical Engineer* will be limited, and furnished only to those subscribers who desire to bind their copies. Requests for the yearly index should be sent to the Circulation Department of the *Railway Electrical Engineer* not later than January 1, 1922.

Car Lighting Maintenance

The maintenance of car lighting equipment is a very real and ever present factor which must be dealt with in no prefunctory manner if the lighting service is to receive the stamp of approval by the traveling public. The demands for more and better illumination in railway trains are apparently without limit and yet progress in this direction has been really wonderful since the advent of the tungsten lamp.

While the demands for lighting of ordinary coaches are seemingly high, they can scarcely be considered so when compared with the greater demand of the Pullman coaches. In consideration of the increased cost of traveling in Pullman cars, it is to be expected that the lighting facilities would exceed those of the ordinary day coach. The Pullman Company has met the requirements for excessive current consumption most satisfactorily and in doing so has developed many remarkable time and labor-saving devices. The article on page 430 of this issue describes the Buffalo repair shops of the Pullman Company and the various methods which have been adopted for speeding up the work are full of interest for the car lighting man.

The Superpower Survey

A plan for using electric operation on 11 eastern railroads is included as a part of the Superpower Survey report which was submitted to the President on November 5. A brief abstract of that part of the report which deals with railroad electrification is published elsewhere in this issue. The plan provides for the consolidation of the power supply in a large eastern district, and without doubt this would permit the development and delivery of power at a lower cost than is now possible, a much better load factor could be obtained, less coal would have to be moved and a number of other savings could be made. It is highly improbable, however, that the report will influence railroad electrification materially in the near future.

It is maintained in the report that 58 per cent of the track owned by 11 of the roads in the district could be electrified with an annual saving equal to 14 per cent of the total cost of electrification. This estimate is based on the assumption that a consolidation of railroads be put in effect that would make it possible to pool all power, allocate certain tracks to freight or passenger service exclusively, consolidate repair shops, etc. No plan is suggested as to how this consolidation might be brought about.

There are tremendous difficulties in the way of effecting such a consolidation. The point might be brought up that the Interstate Commerce Commission, under a provision of the Transportation Act, has suggested consolidations. It must be borne in mind that these consolidations are voluntary, that they must consider present traffic relationships and must retain insofar as possible a measure of competition. Whether the requirements of the Transportation Act can be reconciled with the suggestions of the Superpower Survey report is highly problematical.

It will be difficult too to get the railroads affected to accept the report as it stands because it savors of partisanship. For example, the report assumes that 7.5 lb. of coal are required by a steam locomotive to do work at the rim of the drivers equal to one kilowatt hour. Tests were made on the C. M. & St. P. in 1910 on locomotives not equipped with fuel saving devices which showed this value to be 7.56 lb. Even if the value of 7.5 lb. is correct for the average steam locomotive now operating in the zone in question, it will not be true of steam locomotives in operation in 1925 or 1930, at which time it is proposed to have the superpower system in operation. Beyond any reasonable doubt, electric operation is a means for saving a considerable amount of coal, but there is need for comparative and more modern information based on tests made with modern steam locomotives.

A steam locomotive equipped with economy devices is spoken of in the report as a "full-jewelled movement." It is true that many enginemen speak of the devices applied to steam locomotives as jewelry, but to use the expression "full-jewelled movement" in a report of this character savors of partisanship.

Because of these, and similar statements, the data presented in the report will be accepted by railroad men with reservations. During the next ten years electric traction is practically sure to be adopted by a number of the roads in question. Much of the data presented in the report will be valuable to those roads considering electrification, but it is not at all probable that the report will be accepted in its entirety.

Letters to the Editor

American Committee on Electrification

To the Editor:

I note in your October number an editorial regarding the report of the Committee on Heavy Traction of the American Electric Railway Association. It seems to me that this editorial is somewhat misleading, especially in the matter of reference to co-operation with the Association of Railway Electrical Engineers.

The American Electric Railway Association attempted this year to obtain co-operation from other organizations interested in heavy traction, and no response was received except from the Association of Railway Electrical Engineers, which was ably represented on the Heavy Traction committee by Mr. Sloan.

It was the idea of the committee to present to the members of the A. E. R. A. data which would not be available otherwise, arranged as seemed best to the committee. The checking and arranging of this data represented a minimum of duplication.

It is agreed that the steam railroads should be most vitally interested in the subject of heavy electric traction, and the move for a general electrification committee might most appropriately come from the American Railway Association or, if not from them, from the American Institute of Electrical Engineers. Since there apparently is some hesitation on the part of these organizations it is felt that the effort of the American Electric Railway Association towards co-operation is justified.

Sidney Withington, Electrical Engineer
Chairman, Heavy Traction Committee, American Electric Railway Association.

Location of Headlight Generators

To the Editor:

I have read the article entitled Convenient Headlight Maintenance contained in the *Railway Electrical Engineer,* September issue, and the only thing that I can see is that the writer of this article had but one thought in mind, and that is this, a method of inspecting and repairing a turbo-generator with practically no effort on the maintainer's part.

He apparently did not take into consideration the turbo-generator from an operating standpoint, the conditions that you are up against with this kind of an installation in cold weather, snow and ice that accumulates in heavy snows, especially on the front end of a locomotive under the smoke-box and the consequences and trouble that you run up against in this kind of an installation. Freeze-ups would occur, electrical troubles would originate from dampness, etc. The steam would be in such a condensed form by the time it reached the turbine from such a length of feed pipe that you would not get the efficiency out of the turbine. This, of course, applies to locomotives, you understand, operating in cold weather.

In my opinion the best installation for turbo-generators on a locomotive, taking everything into consideration from a maintenance and also operating standpoint, is the placing of the turbo-generator in a parallel position with the boiler of the locomotive, turbine end of the equipment facing the forward end of the locomotive and generator end not less than 3 ft. from cab, and mounted on a suitable bracket just above the hand rail position, preferably on the left side. An equipment mounted in this position gives the maintainer plenty of room to do his work. It requires a very short feed from the boiler connection to the turbine under the jacket, and also placing the drain line under the jacket, avoiding any possible chance of freeze-ups and at the same time gives you steam to the turbine in the same condition as when it leaves the fountain.

Taking an installation of this kind the maintainer, if he is the right kind of a man, when he makes an inspection will mount the locomotive in front, inspect his pilot wiring, examine his headlight case, wiring and number light, wire between his headlight case and hand rail or conduit, and, passing on his way back to the turbine, he can examine his conduit to the hand rail to see that all clamps are tight, check up on the turbo-generator, and make an examination of all wiring next to the cab.

Notwithstanding the fact that locomotives operating in climates where there is no cold weather would overcome a lot of these bad features, taking everything into consideration as above mentioned with the installation I speak of, I believe will apply equally as well on locomotives operating in warm climates, as well as locomotives operating in parts where there is cold weather.

I would appreciate very much to know what installation the majority of the roadmen take favorably to. The installation I have given you, in my opinion, at the present time is the best we have, but if there is any better, I would be glad to know just what kind it is.

L. A. M.

New Books

Railway Signaling. By Everett Edgar King. 6 in. x 9 in. Bound in cloth. 370 pages, illustrated. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York.

The book represents a compilation of practices common to signaling on the various roads, the subject matter being arranged so as to be specially adapted to a beginner in signal work. The author has drawn largely upon the Proceedings of the Railway Signal Association for his material, and also from the *Signal Dictionary* and *Railway Signal Engineer.* The discussion proceeds in a logical manner, beginning with a brief historical outline of the development of signaling. Various types of signals and signal indications are discussed and illustrated. Chapter three is devoted to an explanation of the fundamental principles of mechanical locking and the four chapters following this treat comprehensively of mechanical, electro-pneumatic, and electric interlocking plants and equipment. Both direct current and alternating current track and signal circuits are discussed at length as well as the numerous types of alternating current relays used in signal work. The manual block system is treated in a special chapter describing the manual block, the controlled manual block and the electric train staff. Automatic signaling on double track lines is discussed with reference to direct current and alternating current track circuits. The various signal mechanisms manufactured by the several signal equipment companies are described and illustrated. The final chapter is devoted to a discussion of highway crossing signals. In general the book is abundantly illustrated and contains much information that is of value not only to the novice in signaling but to the more experienced man as well.

Electric Traction Proposed for 11 Railroads

By Consolidating Power Supply, Electric Operation Could be Made to Show Saving of 14 Per Cent

A REPORT called the Superpower Survey was transmitted to the President on November 5 by Secretary of the Interior Fall. It is the result of an investigation of the possible economy of fuel, labor and material resulting from the use of a comprehensive system for generating and distributing electricity to transportation lines and industries. The investigation was made by a staff of engineers working under the direction of W. S. Murray, consulting engineer, New York; in preparing the report they have endeavored to show how the economies of a power system on so large a scale will affect not only coal, but capital expenditures as well, and especially the output of human energy.

The plan provides for the interconnection of a large number of existing plants in the area shown in several of the illustrations by high voltage transmission lines. These lines would include and be extended to other points at which large power plants could be located advantageously at the mouths of mines, at tidewater, or along rivers suitable for hydro-electric developments. It would be necessary to derive more than 80 per cent of the power from coal. The maximum size of steam-electric stations has been fixed at 360,000 kilowatts. This limit has been determined by considering on the one hand the ability to transmit energy away from the plant and on the other the hazard incident to the possibility of destruction through unusual catastrophe. A steam pressure of 300 lb. would be used at the turbine throttle with a superheat of 230 deg. F. Proposed coal delivery routes are shown in one of the illustrations and six months' storage capacity for each plant is recommended.

Hydro-electric plants will be limited in size by stream flow and storage capacity. The principal developments are located on nine rivers, but as proposed the estimates for 1925 and 1930 can be justified only if they are included in an interconnected system, as otherwise their output cannot be economically absorbed by the power market.

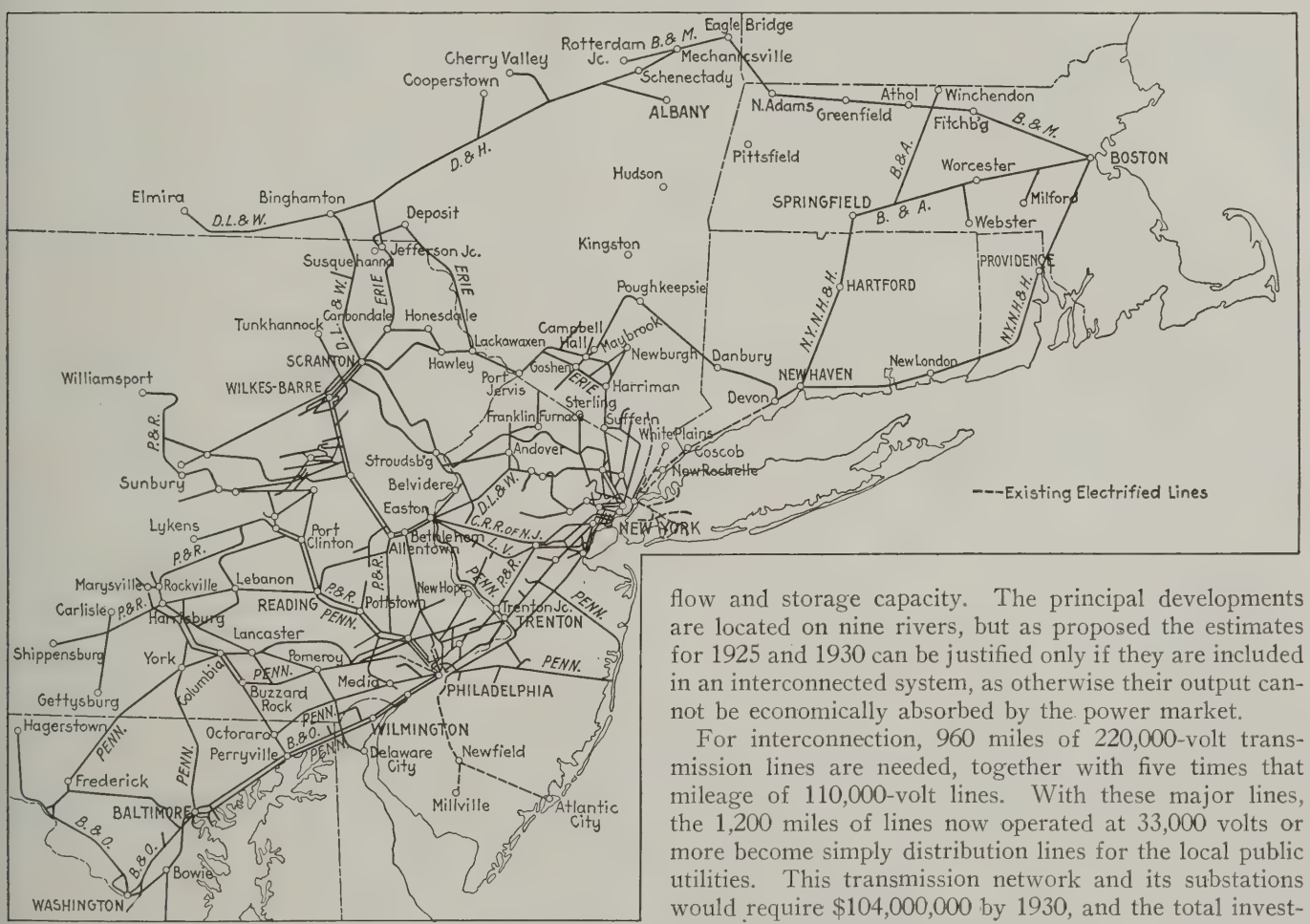


Fig. 1—Map Showing Class 1 Railroads Within the Superpower Zone for Which Electrification Is Recommended

For interconnection, 960 miles of 220,000-volt transmission lines are needed, together with five times that mileage of 110,000-volt lines. With these major lines, the 1,200 miles of lines now operated at 33,000 volts or more become simply distribution lines for the local public utilities. This transmission network and its substations would require $104,000,000 by 1930, and the total investment cost of the system the same year is given by the engineers as $1,109,564,000, of which $693,218,000 would be new money, since more than $400,000,000 worth of existing steam-electric and hydro-electric plants are retained in service.

Electric Operation for Heavy Traction Railroads

The section of the report devoted to the electrification of the heavy-traction railroads was compiled under the direction of Cary T. Hutchinson and N. C. McPherson; it presents results of even more general interest than the detailed analysis of the industrial use of electric power. The question of railroad electrification must be decided

according to density of traffic; on this basis of the 36,000 miles of main line, yards, and sidings in this superpower zone, about 19,000 could be profitably electrified. This electrification would cost nearly half a billion dollars, but it is estimated that it would save from 11 to 19 per cent on the investment, or an average of 14 per cent per year. The following paragraphs contain an outline of the salient points brought out in this part of the report:

A consolidation of the roads within the district in question is first suggested which would make it possible to reroute much of the traffic as now handled. Unified operation by electricity would give much better conditions than any that could possibly be attained under unified operation by steam. There would be a new motive power, in which all units or parts designed for similar service would be identical and interchangeable. There would be a pooling of all power, with great reduction of reserves. Repair shops would be consolidated, and maintenance would become a standardized manufacturing job. Track capacity would be greatly increased, and certain

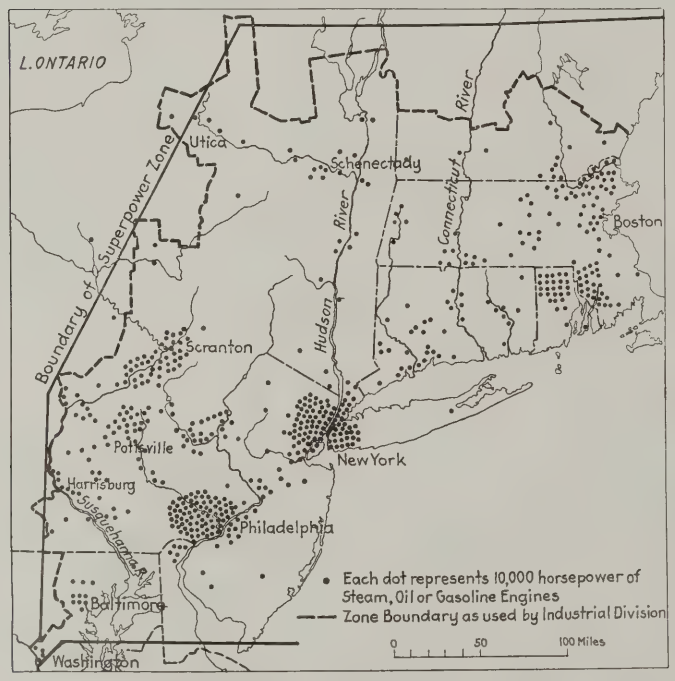


Fig. 2—Isolated Industrial Plants in the Superpower Zone

tracks would be allocated to freight or passenger service exclusively. All freight trains would be run on schedule; the average speed would be more nearly the same and would be increased to at least 12.5 miles an hour needed to avoid the present punitive overtime payments. Enginehouse facilities would be much simplified by consolidation.

The great expense of any large increase in trackage should of itself force electrification; the total cost 20 years hence will be less if electrification is begun now than the cost of the added track and terminal facilities necessary under steam operation to provide for the inevitable 100 per cent increase in traffic within that time.

Motive Power

The entire freight service in the superpower zone can be handled by electric freight locomotives having two articulated two-axle trucks, each carrying two motors geared to the axle, the mounting being essentially the same as that in a number of locomotives now in use and similar to the usual street-car mounting. There would be two classes of locomotives of this type—a light one carrying 80 tons on drivers and having a continuous drawbar pull of 22,000 lb. at 25 miles an hour, and a

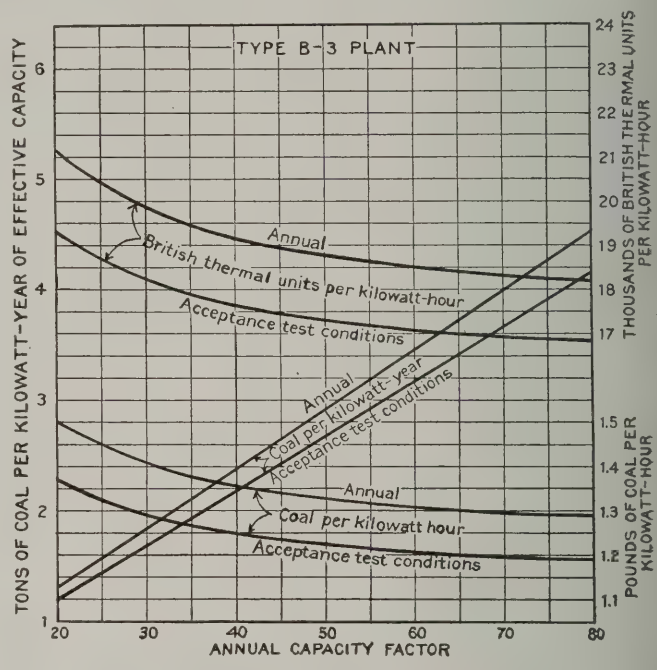


Fig. 3—Estimated Unit Performance of One of the Base-Load, Steam-Electric Plants; Plant Uses Bituminous Coal, Stokers and 20-Tube High Boilers

heavy one carrying 110 tons on drivers and having a continuous drawbar pull of 30,000 lb. at the same speed. These units can be combined in any reasonable number; the total load on drivers can be made equal to 80, 110, 160, 190, 220 tons, or as much more as may be desired,

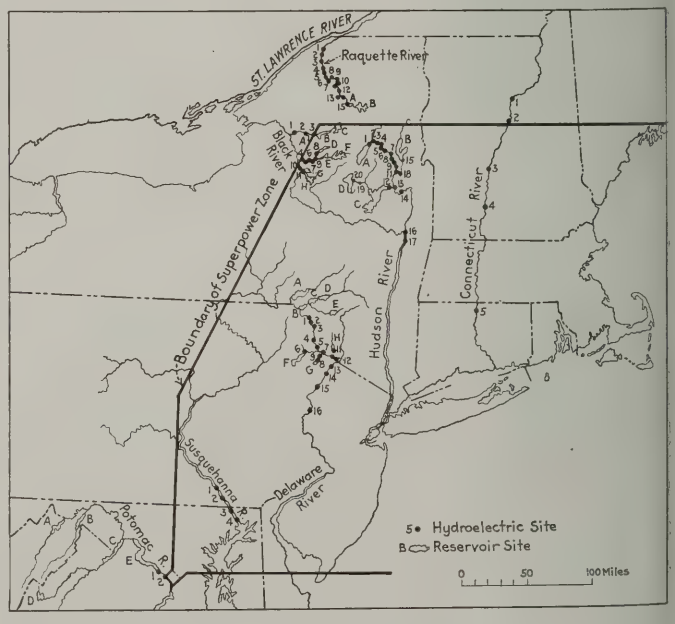


Fig. 4—Principal Hydro-Electric Resources of Superpower Zone

being limited only by the strength of the draft rigging. A train can, of course, be double-headed, and a total tractive pull up to the maximum now in use can be obtained, with at least double the present speed.

For passenger service a similar arrangement would be used; that is, two articulated two-axle trucks, with one motor geared to each axle. The motors may be practically the same as those in the freight locomotives, the only difference being a change in gear ratio. The passenger locomotive, however, would have leading and trailing trucks, with either two or four wheels, and the total weight would be redistributed. This passenger locomotive would be of two weights, the light one having 60 tons on drivers, and the heavy one 90 tons. These also may be combined, like the freight locomotives.

For the switching locomotives, one size will be adequate, with 70 to 75 tons on drivers, of the same type as the freight locomotive. Substantially the same frame and running gear can be used, with motors of less capacity.

All three types of locomotives will have the usual overload capacity, and all will be able to operate in starting and accelerating at 25 to 30 per cent adhesion. These suggested sizes and types of locomotives can, of course, be varied greatly without sacrificing the advantage of unified electric operation, but identity of types for the same service throughout the superpower zone is essential.

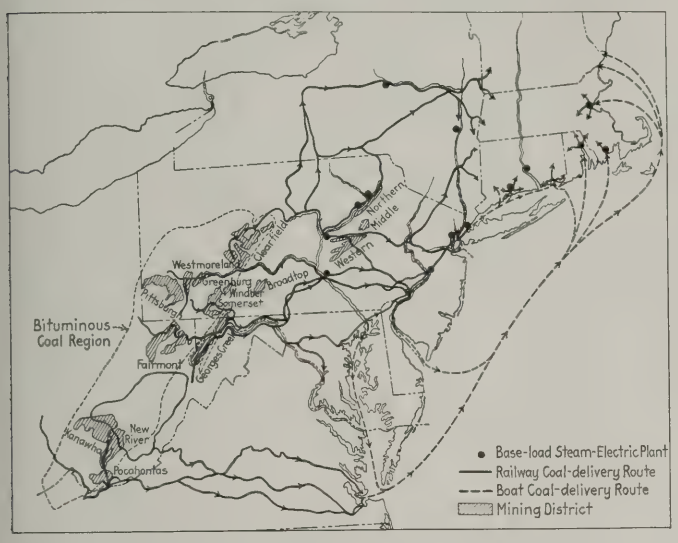


Fig. 5—Location of Principal Coal-Delivery Routes from Bituminous Regions to Base Load Steam-Electric Plants in 1930

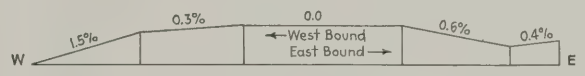


Fig. 6—Profile Used for Making Calculation of Power Requirements

The only two systems that are applicable to general traction within the superpower zone are the 3,000-volt direct-current system and the 11,000-volt (or higher) alternating-current system, both with overhead distribution circuits and rail return. Both of these systems are in successful use, and both can no doubt be designed and constructed to give satisfactory service in the zone.

Class 1 Railroads Within the Superpower Zone

Boston & Maine	Erie
Boston & Albany	Delaware, Lackawanna & Western
New York, New Haven & Hartford	Lehigh Valley
New York Central	Central of New Jersey
Delaware & Hudson	Long Island
Ulster & Delaware	Pennsylvania
New York, Ontario & Western	Philadelphia & Reading
Lehigh & New England	Western Maryland
Lehigh & Hudson River	Baltimore & Ohio

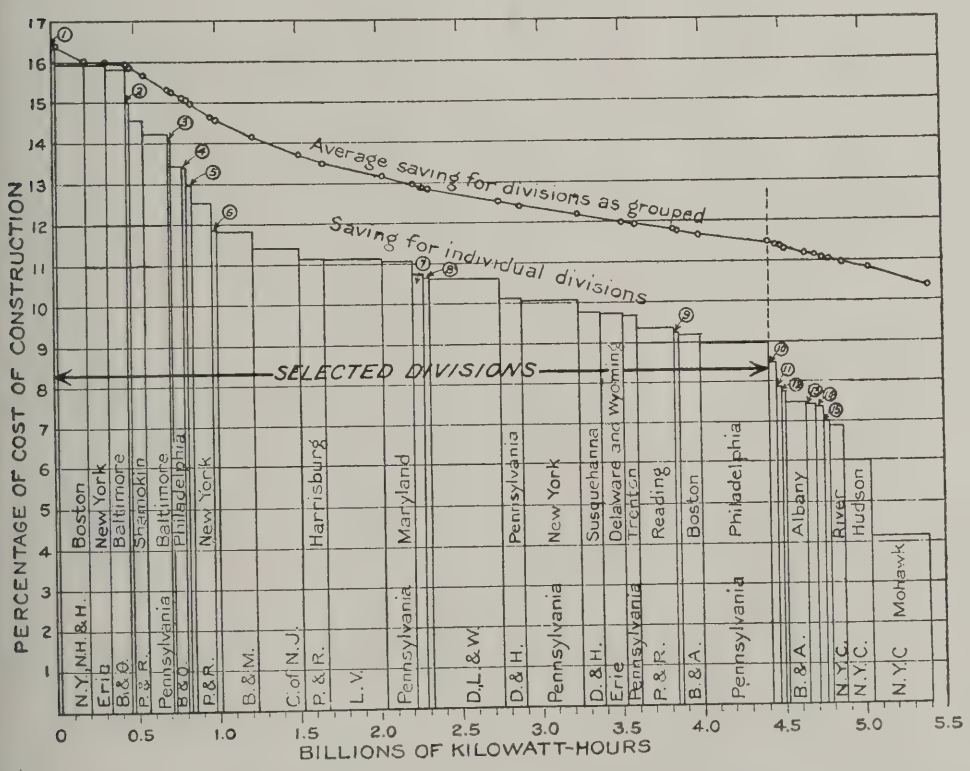


Fig. 7—Saving Effected by Electrification of Heavy-Traction Railroads in Percentage of Construction Costs, Not Including Savings in Wages

Systems of Electrification

In order to avoid some uncertain elements in the estimates of the cost of the alternating-current system it was decided to base all estimates, both of operation and of construction, on the 3,000-volt direct-current overhead system. Substantially the same results in money could, however, be obtained with the alternating-current system, certain gains being offset by certain losses.

It was evident at the outset that it would not be adequate to study the roads as units, but that a study should be made of the operating divisions of the railroads. A study of a railroad system as a whole, even if it lay entirely within the zone, would yield only average results, which might make a poor showing, whereas some of the divisions treated separately might make a good showing. It was, therefore, decided to ask each of the Class 1 railroads within the superpower zone, of which a list is given above, to answer questions asking for certain fundamental data as to roadbed, equipment and traffic. This information, as with all other information sought, was to cover the year 1919.

In addition to the data from the railroads, two large companies, the General Electric and the Westinghouse, were asked to prepare estimates of cost of substation equipment, of electric locomotives, of catenary construction, and of other facilities—all as of the year 1919. Similar data were also asked of the Ohio Brass Company and one or two other companies.

Electrical Energy Required

The electric energy required for the railroads is determined from the records of lines already electrified, with proper allowance for variations in the conditions of operation, and from calculations based on the profile and the alinement of the roads considered and the efficiency of their locomotive and distribution systems.

In fixing the units of energy for the different operating divisions much weight is given to the results of the New Haven service modified as required by profile and alinement under examination.

Other records of electric energy for locomotive-drawn trains, both freight and passenger, were obtained from the Chicago, Milwaukee & St. Paul, New York Central and the Pennsylvania. Tables published in the report show the amount of power used on these roads for freight, passenger and switching service.

The second method of determining electric energy required consists in calculating, from profile and alinement, the work due to normal train resistance and adding to this the net work done against gravity, plus the work due to curvature, plus the work due to acceleration. For example, on the profile shown in Fig. 6, for eastbound movement, it is assumed that no power is required to descend the 0.6 per cent grade, but no credit is taken for use of the kinetic energy accumulated at the bottom of this grade in ascending the next grade; for westbound movement it is assumed that no power is required on the 0.3 per cent grade for freight service, but that the difference between 0.3 and 0.5 per cent is used for passenger service. The lifting work is taken as the sum of the separate lifts; the work against curvature is the sum of the products of degrees of curvature taken from the alinement charts, multiplied by length of curve, and the unit resistance is taken at 0.8 pound per ton per degree. In freight service an acceleration from rest to 25 miles an hour and another from 10 to 25 miles an hour is assumed for each 10 miles. The sum of these elements gives the total work required at the rail to move a ton over the division considered. This process is carried through for movement in both directions, and the average of the two results is taken for the work required. This average divided by the efficiency from rail to substation input gives the watt-hours per ton-mile measured at the substation. For divisions on which the traffic is greatly unbalanced separate estimates were made for the eastbound and westbound movements.

Calculations made for a number of the operating divisions within the zone that differ most widely in grade and alinement show that the added resistance in freight service due to grade, curvature, and acceleration ranges from 0.5 to 10 pounds per ton. The maximum figure is that for the Jefferson division of the Erie, which includes a straight climb over a divide in both directions.

Cost of Electrical Equipment and Saving Effected By It

The quantity of coal burned by a steam locomotive necessary to do one kilowatt-hour of work at the rim of the drivers is estimated at 7.5 lb. Equivalent coal for electric locomotives is uniformly taken at 2 lb. per kilowatt-hour for energy delivered at the substation. All losses of energy in transmission and conversion from the power station to the substation are included in this figure. To make the costs justly comparable throughout, a unit price was adopted for railroad coal in each section: the cost per ton as thus fixed for the several sections of the zone is $5, $5.50 and $6 for the south, central, and northern sections, respectively. These costs include the prorated cost of fuel and water stations.

It is assumed that the railroads will purchase electrical energy delivered at high pressure at substations on or near the railroad right-of-way at the flat rate of one cent per kilowatt-hour.

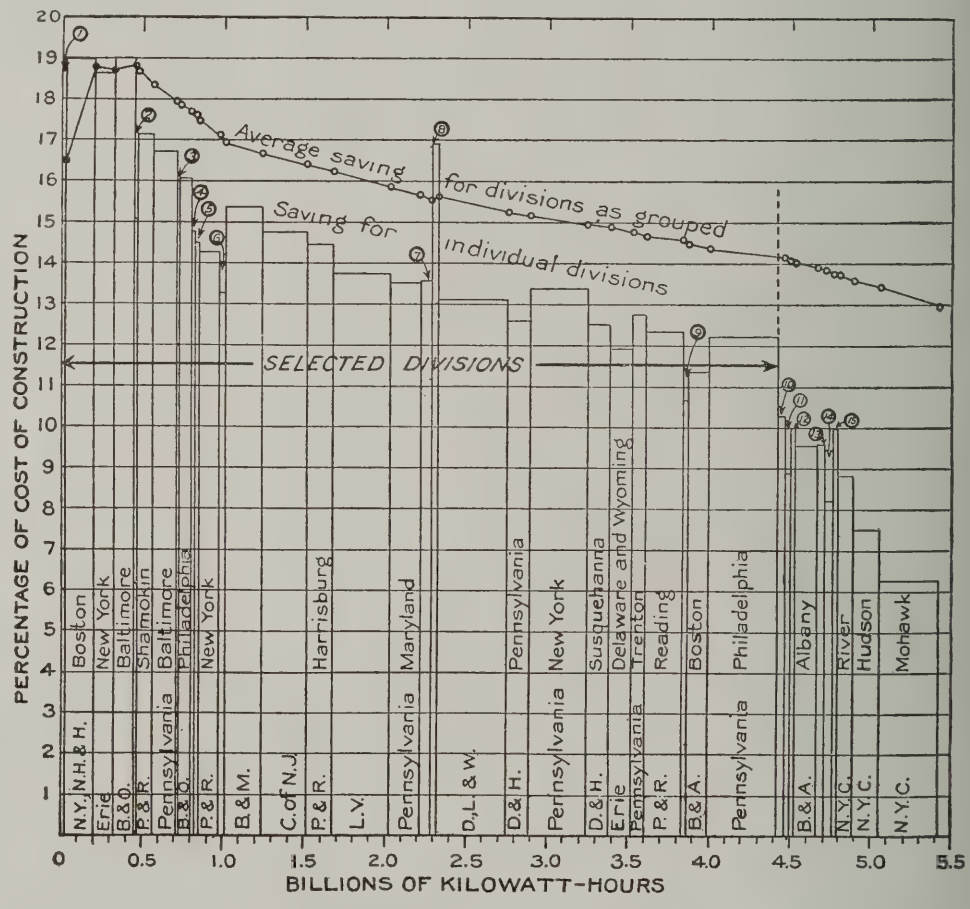


Fig. 8—Saving Effected by Electrification of Railroads, in Percentage of Construction Cost, Including Saving in Wages

Maintenance of the electric distribution systems is taken at $600 per mile for main track and $400 per mile for yard track. The cost of operation and maintenance of substations is based on $1.50 per kilowatt per year of capacity, giving 0.7 mill per kilowatt-hour for a capacity factor of 25 per cent.

It is assumed that there will be an increase in ton-miles

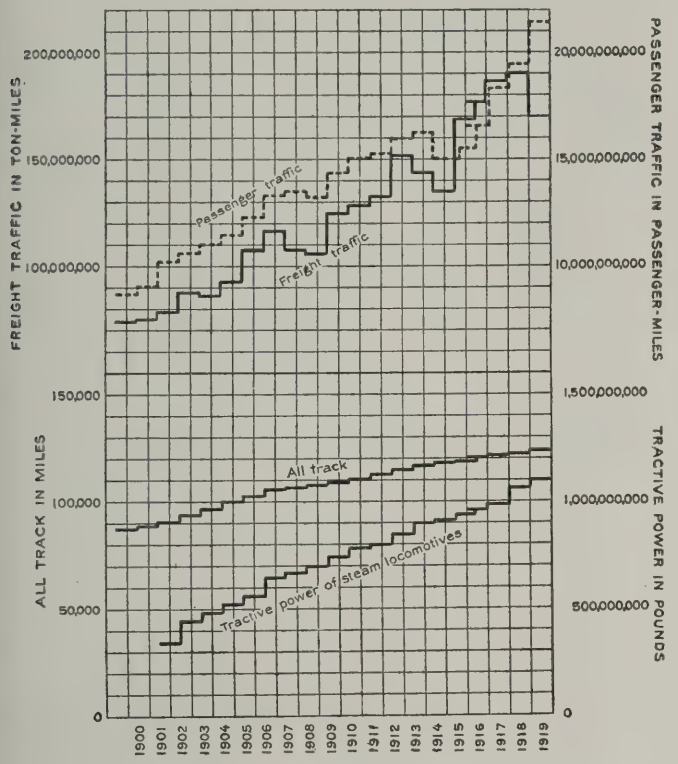


Fig. 9—Growth of Steam Railroads in the Superpower Zone, 1900 to 1919

per electric locomotive-hour of 33 per cent and a consequent reduction in crew wages per ton-mile of 25 per cent. For passenger service no data are at hand; a general consideration of the subject does not indicate a material saving in wages necessary on account of train crews and therefore none is assumed.

TABLE NO. 1
COST OF CATENARY SYSTEM AND ELECTRIC EQUIPMENT

		Miles / Capacity / Number / Total tonnage	Cost	
(1)	Catenary system:			
	(*a*) Single track	175	$2,013,000	
	(*b*) Double track	68	1,700,000	
	(*c*) Three-track	9	291,000	
	(*d*) Four-track	42	1,625,000	
	(*e*) Yards and sidings	221	1,658,000	
(2)	Total	.....	.....	$7,287,000
(3)	Substations ..... kilowatts	82,100	.....	4,926,000
(4)	Locomotives:			
	(*a*) Freight	43	$3,440,000	
	(*b*) Passenger	55	4,576,000	
	(*c*) Switcher	41	2,657,000	
(5)	Total	139	.....	10,673,000
(6)	Sum of specified items	.....	.....	$22,886,000
(7)	Allowance for unspecified items, 10 per cent of (6)	.....	.....	2,288,600
(8)	Overhead, 20 per cent of (6)	.....	.....	4,577,200
(9)	Total gross cost	.....	.....	$29,751,800
(10)	Credit for released steam locomotives	30,300	.....	*6,060,000
(11)	Net cost	.....	.....	$23,691,800

*Present value.

It is estimated that the electric switchers will do 50 per cent more work per hour than the steam switchers, and that consequently the wage account for the same service will be reduced by 33 per cent.

In table No. 1 are listed costs of electric equipment necessary to make the saving possible with electric operation. The costs given in the table are based on the answers of questions sent to railroads operating within the superpower zone, and the values of track mileage, locomotives, etc., given in the table, are the sum of those values given in the answers received. The total net cost as given in the table represents only the cost of the equipment listed in the table and is indicative of the cost of the larger amount of equipment which could be used economically for electrifying the railroads included in the superpower zone.

Costs of catenary are based on estimates made by manufacturing companies which were checked by estimates made by the Chicago Smoke Abatement Commission's report.

The required sub-station capacity, item 3, table No. 1, is based on an analysis of existing installations.

The number of locomotives required is based on an annual mileage of 40,000 for freight, 75,000 for passenger and 40,000 for switcher locomotives. Estimates of costs of locomotives were based on those made by manufacturing companies. These estimates are stated in cost per lb. for the three classes as follows: 40c. per lb. of total weight for freight locomotives and switchers, and 45c. for passenger locomotives, equivalent to $800 per ton on drivers for freight locomotives and switchers, and $1,300 per ton on drivers for passenger locomotives. The total weight on drivers of the electric locomotives is the product of their number by the average weight on drivers of the steam locomotives on the division. The minimum number of electric locomotives required for each division is 50 per cent of the corresponding number of steam locomotives, even if the number based on mileage is less than 50 per cent.

Item 8, table No. 1, covers overhead allowance of 20 per cent for engineering, interest and contingencies which are difficult to predetermine.

It is assumed that all steam locomotives released by electrification can be used and it is also assumed that the average condition of the locomotives released is 50 per cent new. The value of a new locomotive in 1919 is taken at 18c per lb. of total weight, and the salvage value at 2c. per lb.

Conclusions

Following the procedure outlined in the preceding paragraphs, a study was made for all the Class 1 railroad systems within the superpower zone except the Ulster & Delaware, the New York, Ontario & Western, and the Western Maryland. The first two were omitted after a preliminary examination because their traffic was too light to warrant electrification. The Western Maryland was omitted because only a small part of its traffic is within the zone; the preliminary examination, however, indicates that the Western Maryland traffic would justify electrification. This left a remainder of 13 railroads in the zone that were studied. The Boston & Albany was included with the New York Central and the Long Island with the Pennsylvania. It was not possible in this study to adhere strictly to the limits of every operating division

reported by the ralroads, and some divisions were therefore consolidated into routes. The number of divisions or routes range from one on the Boston & Maine to nine on the Pennsylvania and aggregated 40 for the 13 roads.

The results of the study are given in Figs. 7 and 8, which show for each of the 40 divisions the annual saving, in percentage of the net cost of electrification, plotted against the energy required, in kilowatt-hours per year, together with the accumulated average percentage of saving for the divisions as grouped. Fig. 7 shows the saving exclusive of the saving in crew wages, and the divisions are arranged in the order of percentages. With these results as a criterion of economical electrification the "selected divisions" are assumed to be all that show a saving of nine per cent or more. The group of divisions thus selected shows an average saving of 11.4 per cent. It includes 30 of the 40 divisions examined, comprised in 11 of the 13 systems. The saving, including the wage saving, for the 40 divisions, is shown in Fig. 8. For the "selected divisions" these savings range from 10.6 to 19 per cent and average 14.2 per cent. The total energy required annually for these 30 divisions would be 4,400 million kilowatt-hours, and the maximum demand approximately 850,000 kilowatts.

The low percentage of saving shown by the divisions not included in the selected group, except those of the New York Central, is due to light traffic. On the New York Central the train cost of transportation, the cost of maintaining steam locomotives and the cost of coal per mile are lower than on any other system, owing in part to the fact that this is a water-level road with a large amount of through traffic; these are favorable conditions for economical steam operation and, therefore, afford less opportunity for saving by electrification.

The amount of electrification recommended includes 48 per cent of the route miles, 53 per cent of the main track miles, 64 per cent of the yard track and 58 per cent of all track owned by the 11 selected roads in the district. The net cost of electrification of all the selected divisions would be $570,000,000, and the net annual saving in operation, including the saving in wages, $81,000,000, equal to an average of 14.2 per cent of the entire group, ranging from 10.6 per cent for the New York, Susquehanna & Western division of the Erie to 19 per cent for the New Haven-Boston route of the New Haven.

Tables are included in the report which itemize values under headings as follows: Track mileage of selected divisions, data of steam operation on selected divisions, data of electric operation on selected divisions, coal saved by electric operation on selected divisions, energy required for electric operation on selected divisions, cost of electric track facilities and equipment of selected divisions and comparative cost of steam and electric operation on selected divisions. Another table is included which gives the comparative data for steam and electric operation for all the selected divisions within the zone, aggregated into one operating system. The growth of traffic, both freight and passenger, of track, and of tractive power for the Class 1 railroads in the superpower zone from 1900 to 1919 is shown in Fig. 9. The annual rate of growth has been 5.3 per cent in passenger-miles, 4.5 per cent in ton-miles, 0.75 per cent in all track, and 6.6 per cent in tractive power of locomotives.

The amount of money required for electrification is $570,000,000. This figure is based on costs prevailing in 1919, but at costs as of June, 1921, it would be reduced by 18 per cent, to approximately $467,000,000, and before this construction can be undertaken there would be further material reductions. Probably five years from now the entire work outlined could be done for not more than $400,000,000. Good railroad authorities have stated repeatedly that more than $1,000,000,000 a year is needed by the railroads of the United States for extensions and betterments. The part of this total to be allocated to the superpower zone, as determined by the number of locomotives, would be $150,000,000. The amount required for normal extensions and betterments for three years would, therefore, be sufficient to electrify the 30 selected divisions of the railroads in this territory, with an annual saving of more than 14 per cent. The most valuable feature of the change, however, is not the amount saved, but the great increase in maximum capacity of existing trackage and general advantages of electric operation.

These figures indicate that with a return of normal financial conditions all these lines should be electrified before further great expenditures have been incurred to increase in a minor degree the capacity of the existing tracks and yards. Steam operation cannot satisfactorily meet the conditions of the crowded terminals herein described as the superpower zone; electric operation can easily do it.

Dr. Charles E. Steinmetz, noted electrical engineer, explained the origin of the lightning flash recently at a dinner of the Kiwanis Club.

Dr. Steinmetz's theory, as he explained it, was that great incandescent bodies like the sun continuously send out negative electricity and so are positively electrified, while dark bodies like the earth become negatively charged. The water vapors condensing as raindrops in the cloud therefore have a small electric charge due to the electric field of the earth. When, then, hundreds and thousands of minute drops conglomerate to a large raindrop the minute charges of all the small drops collect on the one large drop. But the capacity of the large drop is very much smaller than the capacity of all the small drops together, and the electricity on the large drop thus is crowded together—that is under high pressure—and in this manner, by conglomeration of many small moisture particles into one large raindrop, the voltage rises until it reaches values sufficient to jump through space as lightning flash.

Photo by Ewing Galloway

Ore Docks on the Lake Front at Cleveland

Electric Arc Welding for Boiler Repairs

Special Committee of Master Boiler Makers' Association Reports Best Methods of Reconditioning Boilers*

THE responsibilities of good welding depend largely upon the skill and experience of the operator.

Welding electrodes that have the approved chemical contents or elements which will give the best tensile strength which conditions may require should be adopted for boiler repairs. Another important point is that welding electrodes which are to be used on firebox welding should have even flowing qualities; that is, the globules of metal should flow from the point of the electrodes to the work in a steady stream, so they will not interfere with the skill of the operator or the functions of the electric arc. The efficiency of the operator should be fully determined before he is allowed to perform any welding in locomotive fireboxes, by having him weld specimens at least once each month. The welded specimens should be forwarded to the engineer of tests who will test them for tensile strength. The efficiency of the welded specimen should be at least 75 per cent of the firebox steel used before the operator is allowed to do any firebox welding.

It is important that good judgment should be exercised in assigning operators to autogenous welding in fireboxes.

Another important feature is that no piece of work should be welded unless it is properly prepared. That is, all seams should be beveled as in Fig. 1, and should be thoroughly cleaned, free from grease, rust, scale and other foreign substances. It is very essential that the weld be made on bright clean metal and that this condition be preserved throughout the entire welding operation. The use of a roughing tool, as shown in Figs. 2 and 3, or a sand-blast machine, may be used for cleaning purposes. All seams should be carefully fitted and beveled to 45 degrees, not allowing more than ¼ inch or less than 3/16 inch space at the bottom of the V, as shown in Fig. 1, as determined by the use of a gage.

If the opening at the bottom of the V closes to less than 3/16 inch, the welder should stop and have it chipped

*This report will be presented at the Master Boiler Makers' Association Convention, which will be held at the Hotel Sherman, Chicago, May 23 to 26, 1922. The report committee consisted of H. H. Servise, supervisor of welding, Atchison, Topeka and Santa Fe Railway, Topeka, Kansas, chairman; I. J. Pool and R. W. Clark.

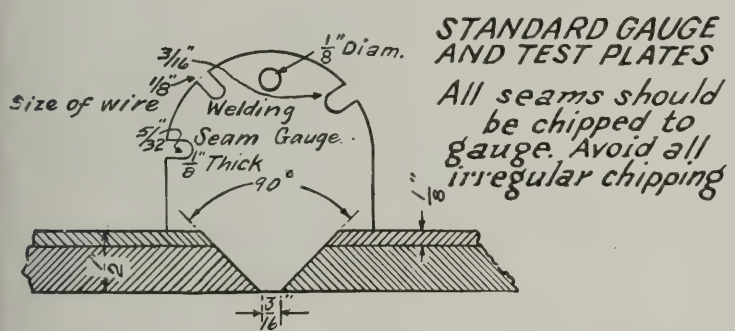
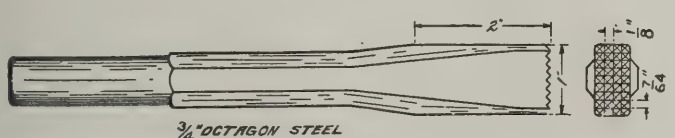

STANDARD GAUGE AND TEST PLATES
All seams should be chipped to gauge. Avoid all irregular chipping
Size of wire
Welding Seam Gauge
90°

Fig. 1—Sheet Beveled for Welding



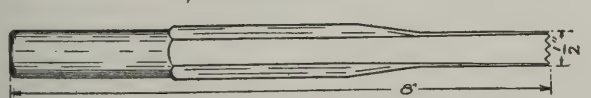


Fig. 2—Tool for Removing Scale

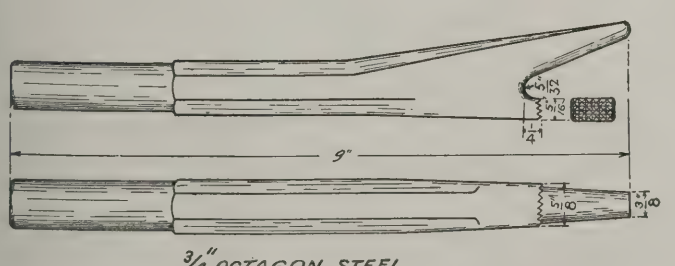


Fig. 3—Tool to Remove Scale from Around Bead

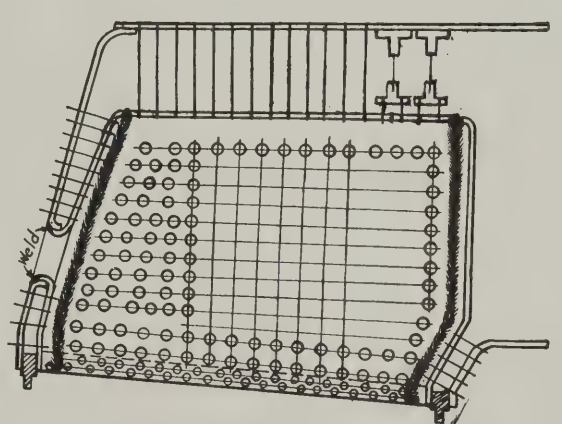


Fig. 4—Method of Welding Firebox

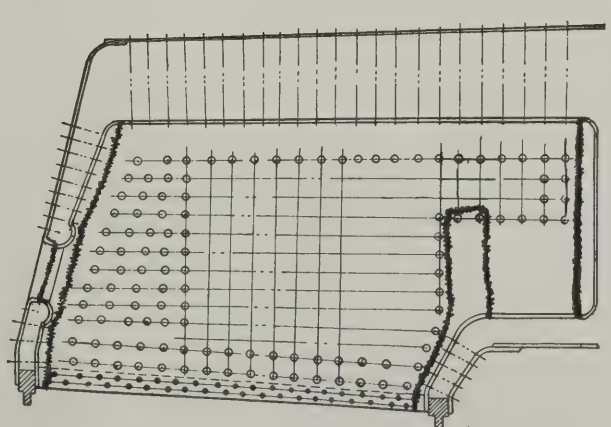


Fig. 5—Welds Firebox and Combustion Chamber

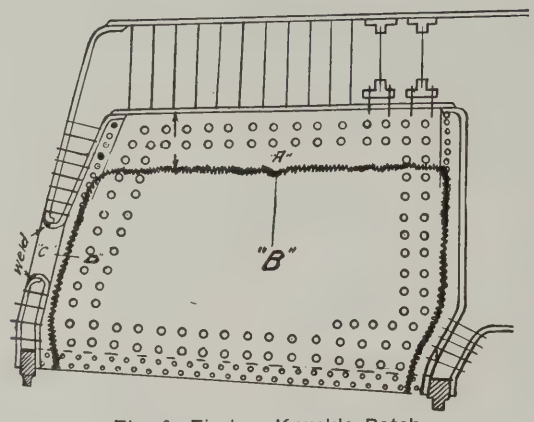


Fig. 6—Firebox Knuckle Patch

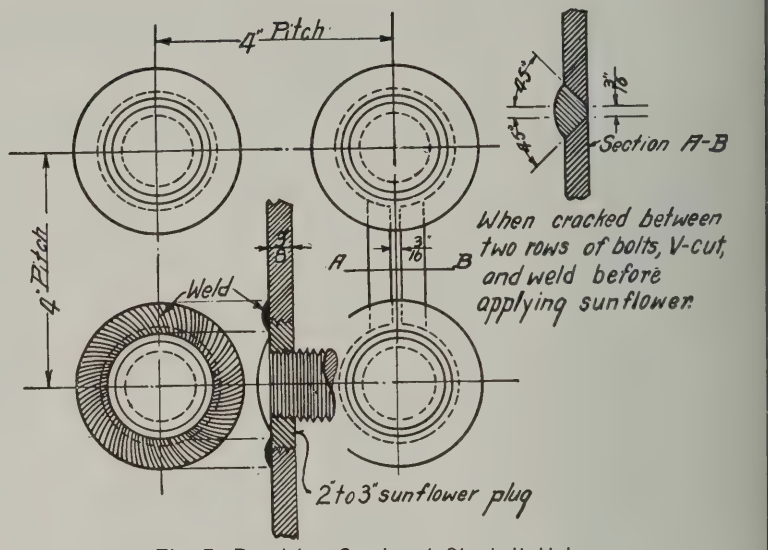
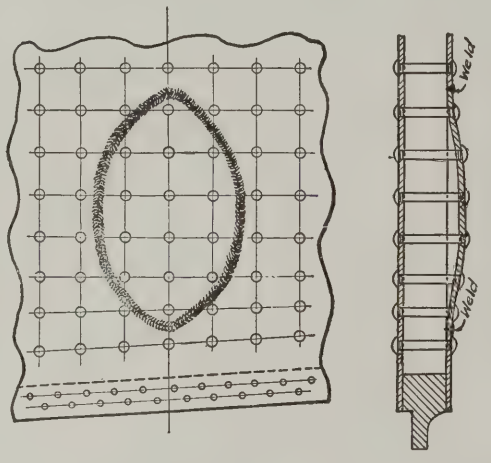
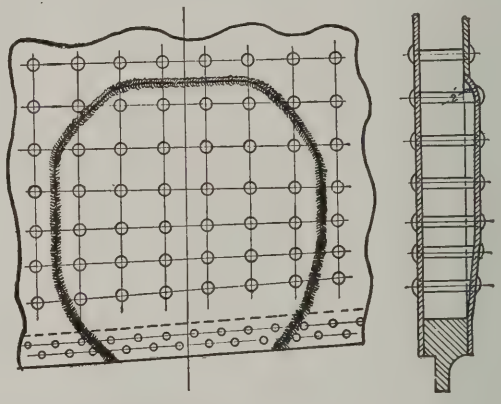


Fig. 7—Repairing Cracks at Staybolt Holes





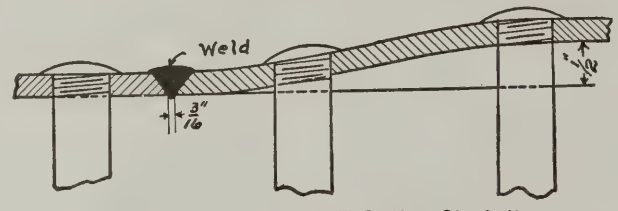


Fig. 8—Patch Around Defective Staybolts

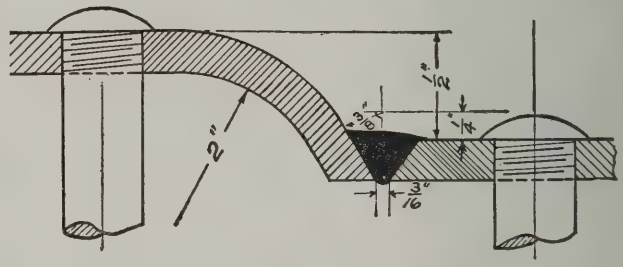


Fig. 9—Side Sheet Patch

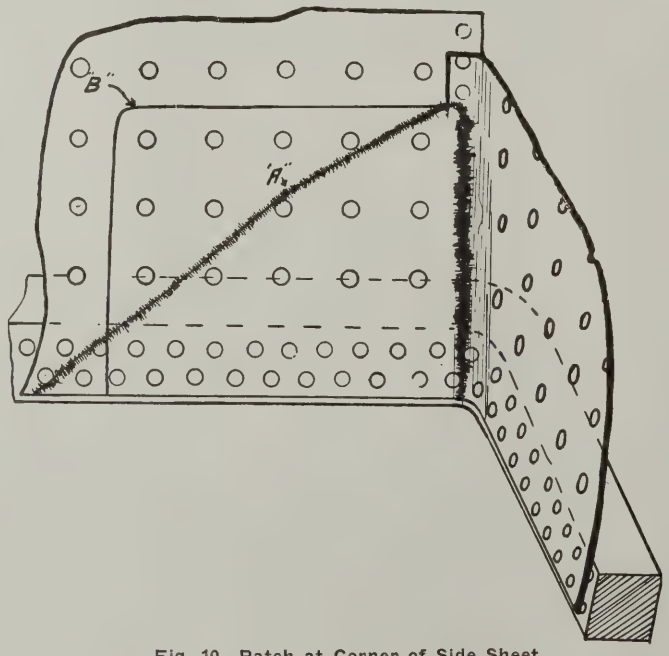


Fig. 10—Patch at Corner of Side Sheet

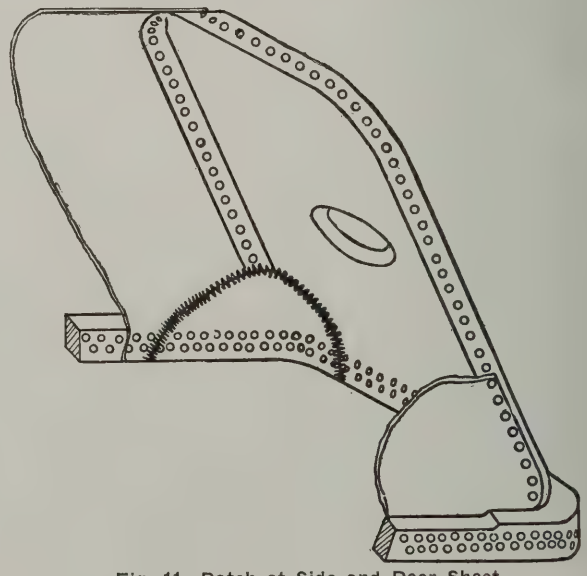


Fig. 11—Patch at Side and Door Sheet

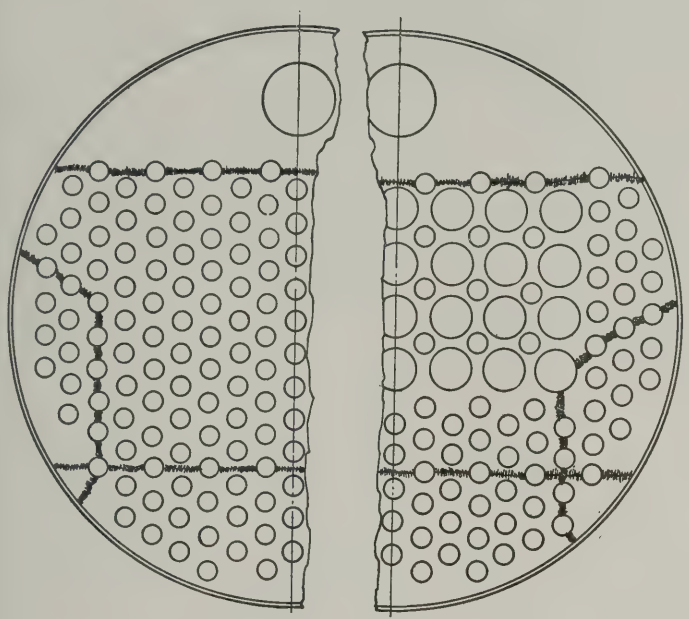


Fig. 12—Welding Patches in Front and Back Flue Sheets

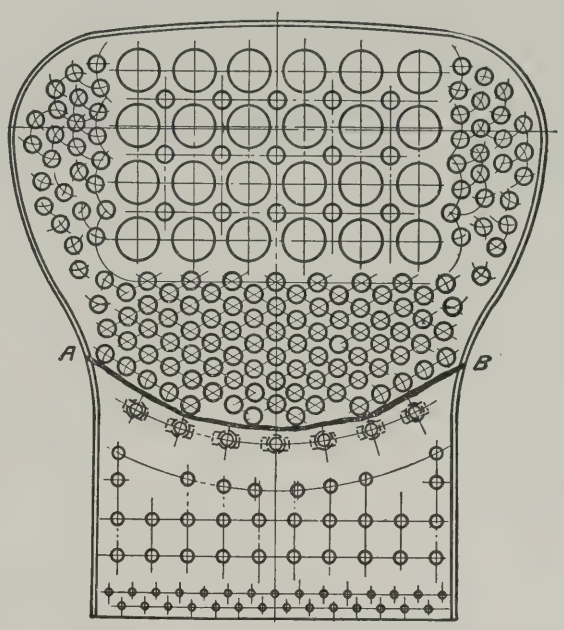


Fig. 13—New Top Portion of Back Flue Sheet Arranged for Superheater

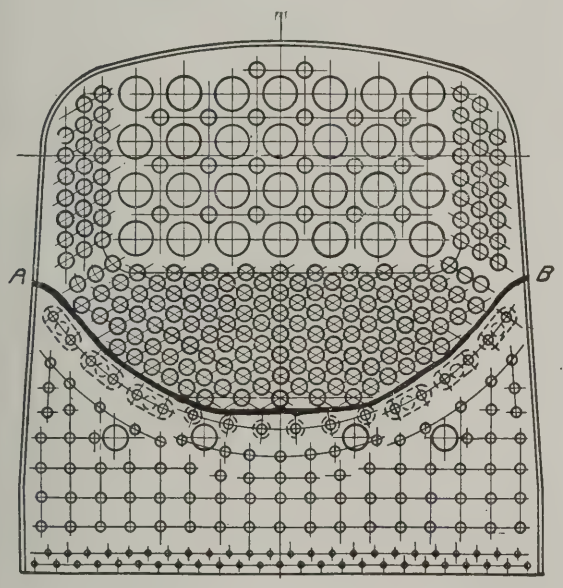


Fig. 14—Wide Firebox Back Flue Sheet with New Top Portion

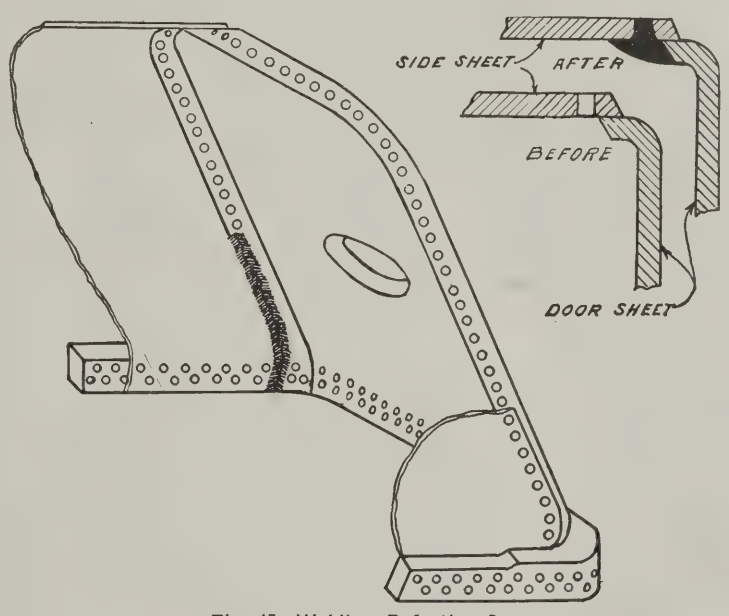


Fig. 15—Welding Defective Seams

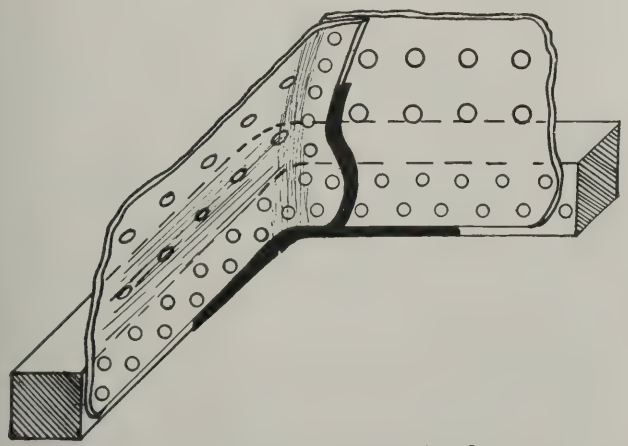


Fig. 16—Repairing Leaky Mudring Corner

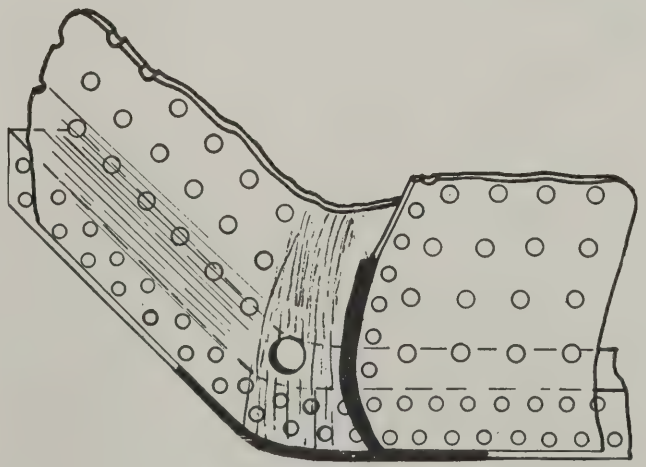


Fig. 16A.—Another Section of the Mudring

to the standard opening. Under no condition should the plate be burned with the cutting torch to enlarge the opening, unless it is going to be chipped afterward.

The following is an approximate comparison of the cost of labor between applying an electric welded three piece Mikado firebox and riveted box of same type.

TABLE 1.—ELECTRIC WELDED FIREBOX

	No. of Men	Rate per Hour	No. of Hours	Cost of Labor
Laying out firebox wrapper sheet with template, complete	1	.90	5	$4.50
Punching wrapper sheet	2	.85 .62	9	13.23
Laying out flue sheet, complete	2	.90 .62	7	10.64
Punching flue sheet, complete	2	.85 .62	5	7.35
Punching door sheet, complete	2	.85 .62	3	4.41
Flanging flue sheet under press	4	.90 .67 .67 .67	1	2.91
Flanging door sheet under press and door hole by hand	4	.90 .67 .67 .67	2	5.82
Rolling wrapper sheet	2	.85 .62	3	4.41
Shearing wrapper sheet	2	.85 .62	1	1.47
Shearing flue sheet	2	.85 .62	½	.74
Shearing door sheet	2	.85 .62	½	.74
Burning flange on flue sheet	1	.90	½	.45
Burning flange on door sheet	1	.90	½	.45
Chipping flue sheet for welding	1	.85	3	2.55
Chipping wrapper sheet for welding	1	.85	5	4.25
Chipping door sheet for welding	1	.85	2½	2.13
Fitting firebox for welding	3	.85 .62 .62	4	8.36
Electric welding in door sheet and flue sheet complete	1	.90	28½	25.65
Total	..	..	..	$100.06

For a riveted firebox, the operation is approximately the same after eliminating the welding and adding the following:

TABLE 2.—RIVETED TYPE FIREBOX

	No. of Men	Rate per Hour	No. of Hours	Cost of Labor
Laying out of rivet holes in flue sheet	2	.90 .62	1½	$2.28
Laying out of rivet holes in door sheet	2	.90 .62	1½	2.28
Laying out of rivet holes in wrapper sheet	2	.90 .62	2	3.04
Punching rivet holes in wrapper sheet	2	.85 .62	2	2.94
Punching rivetholes in flue sheet	2	.85 .62	2	2.94
Punching rivet holes in door sheet	2	.85 .62	1½	2.21
Countersinking rivet holes	2	.85 .62	2	2.94
Reaming rivet holes and changing bolts	2	.85 .62	5	7.35
Riveting firebox	4	.85 .85 .62 .62	5	14.70
Calking firebox inside and outside	1	.85	6	5.10
Total	..	..	..	$45.78
Cost of labor—Riveted firebox				$120.19
Cost of labor—Electric welded firebox				100.06
Saving of welded box over riveted box				20.13

Welding of Complete Fireboxes

All sheets should be beveled on the rivet line from the fire side, Fig. 4, and plates should be fitted into the mud ring, held together with strongbacks or clamps about every 12 inches in order to hold the plates in perfect line. The sheet should then be tack welded between each of the clamps, these tacks being from two to three inches wide. After this operation has been performed, the clamps should be removed and the intermediate spaces welded. Do not remove the firebox from the ring until after the welding has been completed. All seams should be reinforced 20 per cent of the thickness of the firebox sheet on the fire side, and when it is possible to do so, seams should be reinforced on the water side approximately 10 per cent, especially on the crown sheet.

All welding should be started at the bottom of each intermediate space and finished at the top of the seam. For all firebox work current values from 100 to 125 amperes will give the best results when properly handled by the operator using a 5/32-inch diameter electrode. The cost of welding firebox seams per lineal foot is 90 cents for labor, material and current.

Preparing Half Side and Door Sheet for Autogenous Welding—Electric Arc Process

The sheet should be bolted to the mud ring after it has been properly beveled and fitted in place. Staybolts may be applied, except the rows adjacent to the seam which is to be welded. All horizontal seams should be held in place with strut bolts and tack welded every 12 or 14 inches. Then weld intermediate spaces alternating from the center space to the spaces at either end. Vertical seams should be tack welded similar to horizontal seams. After being tacked, start welding at the bottom space and finish at the top space. Current values for successful welding on this operation are the same as for firebox welding described in Fig. 4 and Fig. 5.

Firebox Sheet Knuckle Patch

Preparation for the firebox knuckle patch, Fig. 6, may be followed as outlined for the welding of half side sheets or door sheets. The use of strut bolts can be applied to hold the patch in line when necessary, while it is being tack welded. All strut bolts should be removed after the patch is welded into position. Under no circumstances should the knuckle patch be less than 12 inches from the crown sheet.

Weld the horizontal seam first, then tack weld the flanged sheet to the wrapper sheet. Remove all strut bolts and weld intermediate spaces, working from the bottom on either side of the patch upward, finishing at the top.

The method indicated in Fig. 7 is to be used to repair cracks or staybolt holes in firebox sheets, where not more than 6 sunflowers are necessary to complete repairs, and not more than 4 sunflowers will be joined together. This system may be used in main shop general repairs, sunflowers not to exceed 3 inches in diameter.

Repairing Small Portions of Side Sheet When Defective

When the defective portion does not extend over six staybolts repairs can be made as per instructions given for Fig. 7, which give very efficient results. When the defective portion is larger it is then advisable to use methods as shown in Fig. 8, by removing the defective portion and applying a patch of an elliptical or circular shape. In preparing the patch, sufficient metal should be allowed so that when the patch is dished ⅜ to ½ inch in the center, the opening at the seam should not be more than ¼ inch wide at the bottom of the V and not less than 3/16 inch. The patch should be held in place by strut bolts and tack welded on the right or left side; then weld this seam of the patch before the opposite side is tack welded so as to allow the patch to draw in one direction. After this has been completed, allow it to cool before starting on the opposite side. By so doing there will be only one contraction of the patch. All welding should be performed from the bottom upward. Should

the defective portion of the side sheet extend down to the mud ring rivets, apply the patch as in Fig. 9, the welding operation being the same as outlined for Fig. 8. Should the defective portion be at a location as shown in Fig. 10, the seam may be applied as indicated by line "*A*."

Should the plate at the corner of a firebox become defective and it is necessary to remove a portion of the side sheet and the door sheet, it is advisable to apply a patch to both sheets as in Fig. 11.

Should it be necessary to make repairs according to Fig. 12, Fig. 13 and Fig. 14, the work should be done by welding from the fire side of the sheets and reinforcing them on the water side.

Method of Welding Patch on Front of Crown Sheet

Should it be necessary to repair the front portion of the crown sheet, prepare for welding as outlined previously. A very important feature about this welded seam is that the front point adjacent to the flue sheet should be finished on the flat side of the firebox at least 12 to 14 inches below the highest point of the crown sheet.

Welding of Seams

Should the seams become defective and cause considerable trouble, repairs can be made with the electric arc welding process as is shown in the two Figs. 15 and 16.

Remove the defective portion of the flange which is giving trouble by cutting through the back of the rivet holes, bevel the sheet 45 degrees and tack weld it every 12 inches; then weld the intermediate spaces. The weld should not be any thicker than the flange of the sheet and tapered to a point. Weld the old rivet hole solid as shown in the illustration.

Broken Mud Ring

In case mud rings become broken it is advisable to remove a portion of the firebox sheet. Bevel the mud ring from the top, giving at least ¼ inch opening at the bottom of the V, and reinforce it at the bottom of the mud ring after the weld has been completed on the top portion, afterward applying a patch on the portion of the firebox which was removed. The welding current values for welding mud rings are from 125 to 150 amperes, using an electrode 5/32 inch in diameter.

Door Collar Patch

Should the door collar become defective, the defective portion can be removed and a patch applied as in Fig. 17, following the instructions as described for Fig. 8.

Improper Welding of Firebox Plates

Under no circumstances should welding be allowed di-

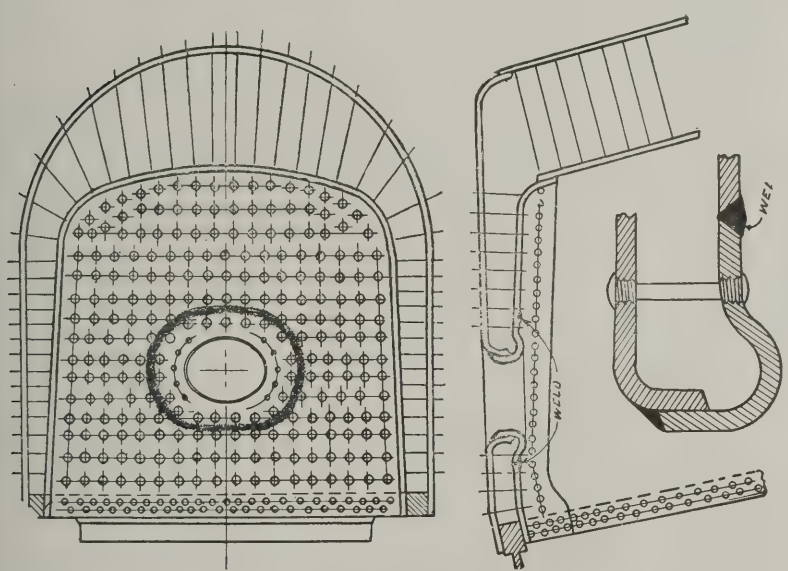


Fig. 17—Door Collar Patch Weld

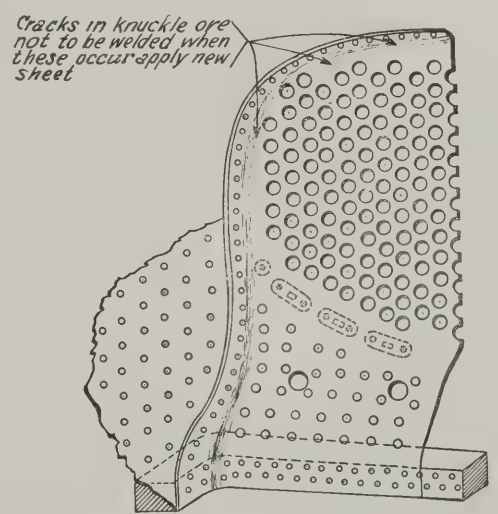


Fig. 18—Welding Should Never Be Used in Knuckle of Firebox Sheets

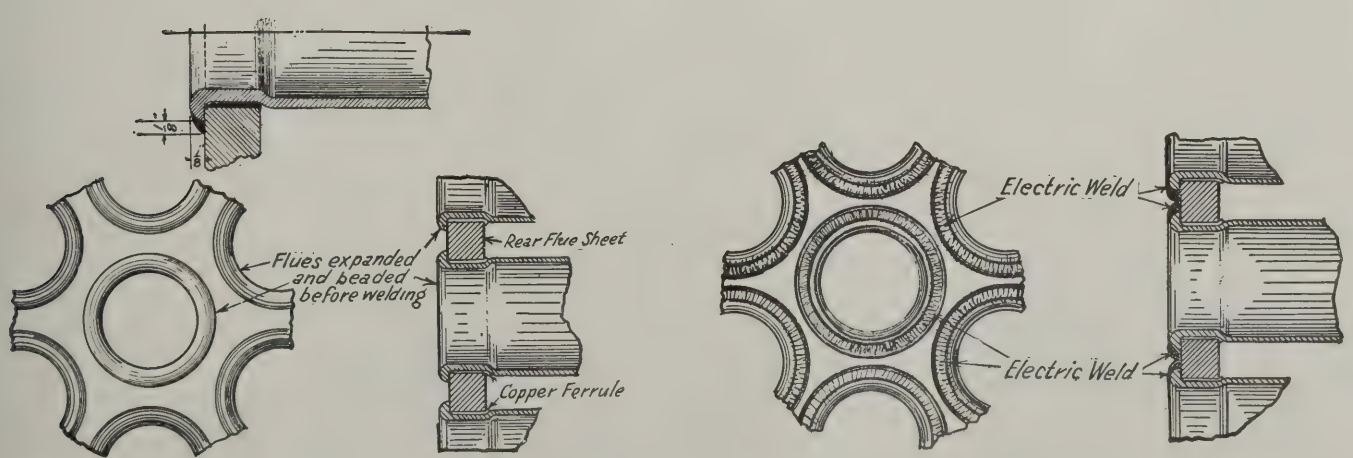


Fig. 19—Method of Applying Flues in Locomotive Boilers by Means of Electric Arc Process

rectly in the knuckles of firebox sheets as shown in Fig. 18. This ruling should be enforced vigorously.

Welding of Flues in Back Flue Sheet

It is very important when applying copper flue ferrules to the flue sheet that, when set and rolled, they do not project out on the fire side of the sheet, so that when the flue is applied the copper will not project under the flue beads. After the flues have been set in the regular manner very good results may be obtained by welding them after having received the second working. That is, if the locomotive is allowed to work its regular turn until the flues are to be reworked the second time, this allows the flues and flue sheets to get a good setting. By so doing it also allows the grease to be burned off the sheet.

After the flues are worked the second time, the sheets should be thoroughly sand blasted. When welding, the top row of flues should be welded first, the second row next and so on until the entire flue sheet has all the flues welded to it. It is very essential that the welding should be started at the bottom of the flue and worked upward, the weld being finished at the top of the flue to secure satisfactory results. It is in this operation that the flowing quality of the electrode is most important and should be given a great deal of consideration. The heat values on this operation vary widely and the operators should use their best judgment according to conditions.

Care should also be exercised on the part of the operator not to apply an excessive amount of metal. If he should do so, the metal will overheat and crack and cause a great deal of trouble. If it should become necessary to reweld a leaky flue which has been welded previously, all the old metal or weld should be removed and the flue worked tight into the sheet.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Charles W. T. Stuart

XVI—Safety Car Lighting Equipment (Continued)

IN the October issue, the Type F Safety equipment was described. The Type F2 equipment, a description of which follows, is a modification of the Type F equipment, designed to meet the Pennsylvania Railroad specifications. The Type F2 equipment may be found also on roads other than the Pennsylvania Railroad.

The F2 equipment consists of a generator, generator regulator, lamp regulator and storage battery.

The Generator

The generator, Fig. 1, is a four-pole, shunt-wound machine, rated at 2 kw. at 40 volts and representing a generator capacity of 50 amperes. The four laminated pole shoes with their field coil retainers are fastened to the magnet frame by through bolts with lock washers and nuts. The cast-iron heads of the generator, which supports the bearings, are bolted to the ends of the magnet frame. Ball bearings, known as No. 412 size, are employed on both the pulley and commutator ends of the shaft, and are lubricated by grease which is enclosed in the heads.

The pole changer is of the rotating type. The friction of the brushes is sufficient to cause the pole changer to revolve through an angle of 90 degrees when the direction of the car motion is reversed. The travel of the pole changer is limited by stops.

Three wires—positive generator, negative generator, and positive field—are brought out through the bushed holes in the generator frame and connect to corresponding terminals on the generator regulator panel. The negative field is connected directly to the negative generator lead inside of the generator frame, as shown in diagram, Fig. 2.

The F2 generator has a cutting in speed of 250 r.p.m. and a full load speed of 333 r.p.m. On a car equipped with 36-in. wheels and an 18 to 8 reduction; that is, 18-in. axle pulley and 8-in. armature pulley, this generator will cut in at a train speed of 12 miles per hour and carry full load at a train speed of 15.9 miles per hour. It will also operate safely at a train speed of 75 miles per hour with wheels worn to the limit. Therefore, this equipment is suitable for either branch line service where the train speeds are low or main line service where higher train speeds are attained.

The F2 armature weighs 215 lb.; the generator, less pulley, 775 lb., and the total weight of generator and suspension complete, is 1,075 lb.

Generator Regulator

The generator regulator, Fig. 3, is rated at 40 volts, 41 amperes, and consists of a slate panel on which are mounted the automatic switch *H*, field rheostat or carbon pile *C*, voltage regulating coil *A* and current regulating coil *S*, with their respective plungers and lever arms, 65 ampere main, and 10 ampere field fuses *O* and *W*, respectively, two resistance units *Q* and *N*, a knife switch *K*-1, and a special resistance coil *R*. The automatic switch *H* consists of a fine wire shunt, or lifting coil and a series, or "kick off" coil of heavy copper ribbon, both surrounding an iron core which forms part of the magnet frame or yoke of the switch. At the bottom is pivoted a movable iron armature to which is attached the laminated conductor of the switch. The two contact surfaces of the switch are protected by secondary carbon contacts so arranged as to be easily renewable.

Referring to the wiring diagram, Fig. 4, note that the lifting coil *J* is connected directly across the generator terminals, while the series coil *K* is connected directly

into the generator circuit. The series coil is known as the "kick off" coil on account of its action. When the generator voltage falls below that of the battery, a reverse current will flow back through this coil from battery to generator. This current will generate a magnetic flux which will oppose the shunt coil magnetism, and when these two forces balance, the switch is opened by the force of gravity. The *N* unit connected in the lifting coil circuit has a resistance of 45 ohms.

The field rheostat or carbon pile *C*, Fig. 4, is connected in series with the field circuit. It is 2⅝ in. long and contains approximately 168 discs, which are 1/64 in. thick and 1⅞ in. in diameter. The resistance of this pile is automatically adjusted by movement of the plungers of the regulating coils. The shunt or voltage regulating coil *A* is connected directly across the generator terminals. The series regulating coil *S* is made of heavy copper ribbon and is connected in series with the main circuit.

The knife-switch, *K*-1, Fig. 3, is used in changing the control from 24 to 41 amperes or vice versa.

The resistance unit *Q*, located above the automatic switch, has resistance of 16.5 ohms, with 12, 13 and 15 ohm taps. It is connected in the voltage regulating coil circuit. This unit is so constructed that a small section of the resistance *XY* can be short-circuited by a round brass rod fitted into suitable terminals.

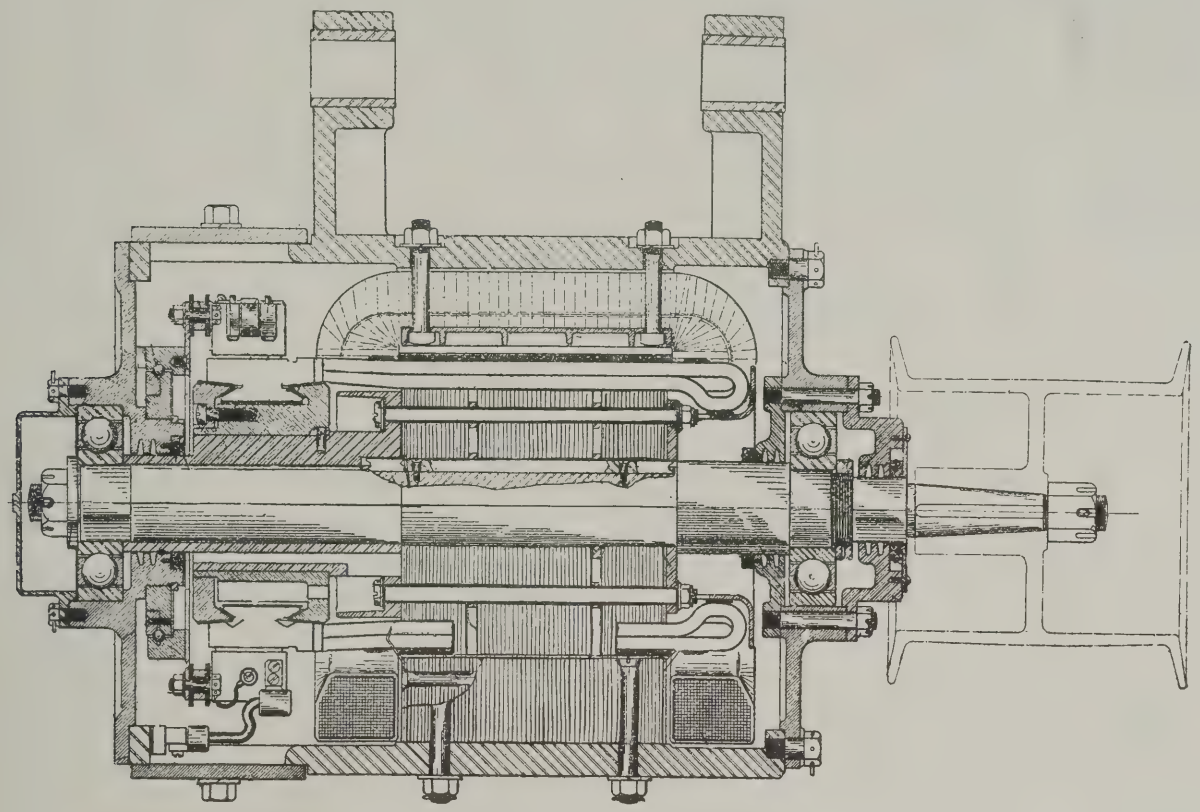


Fig. 1—Type F-2 Safety Generator

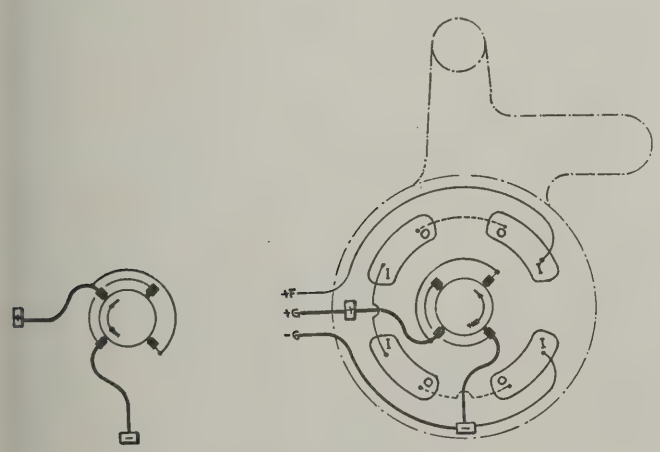


Fig. 2—Diagram of Field Coil Connections

The pull of the regulating coils upon their respective plungers and lever arms is opposed by the pull of the two small spiral springs, *G* and *G*-1. The spiral springs are approximately ½ in. in diameter and 2 in. long. Spring *G*-1 is connected to the voltage regulating coil lever arm, and spring *G* to the current regulating coil lever arm.

The upper end of spring *G*-1 is attached to a pin provided with three small slots. The regulated voltage control may be changed by moving the spring from one slot to another.

Lamp Regulator

The lamp regulator, Fig. 5, is rated at 40 volts, 50 amperes and consists of a slate panel upon which are mounted two carbon piles *E*, electro magnet *M*, and resistance unit *M*-1. Each carbon pile is approximately 6 in. long and contains 48 discs ⅛ in. thick and 2⅝ in. in diameter. The two carbon piles are connected in parallel with each other and in series with the lamps. See Fig. 4. The electro magnet *M* automatically controls the pressure on the carbon piles. The design and operation of the F2 lamp regulator is the same as that for the Type F lamp regulator which was described in the previous article.

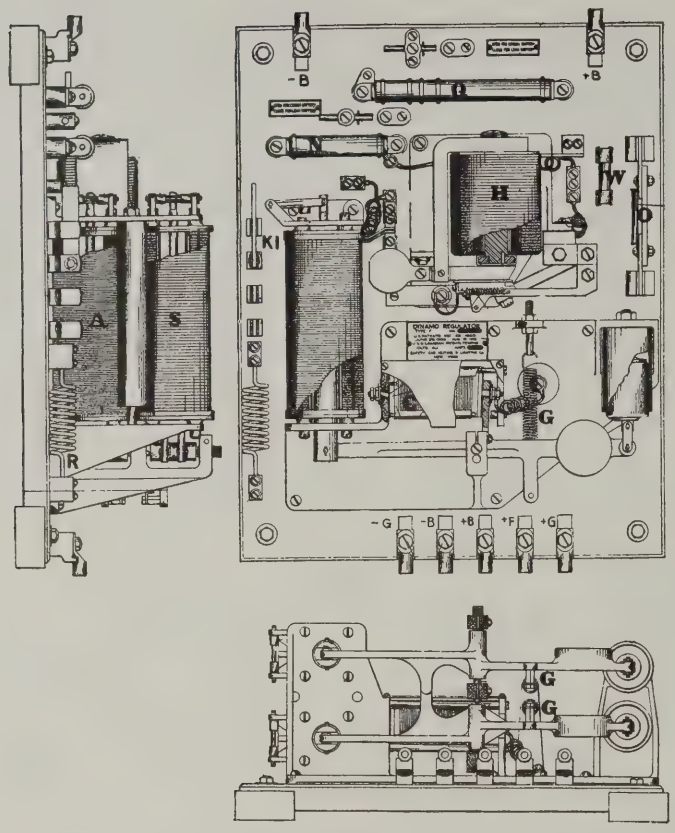


Fig. 3—Type F-2 Generator Regulator

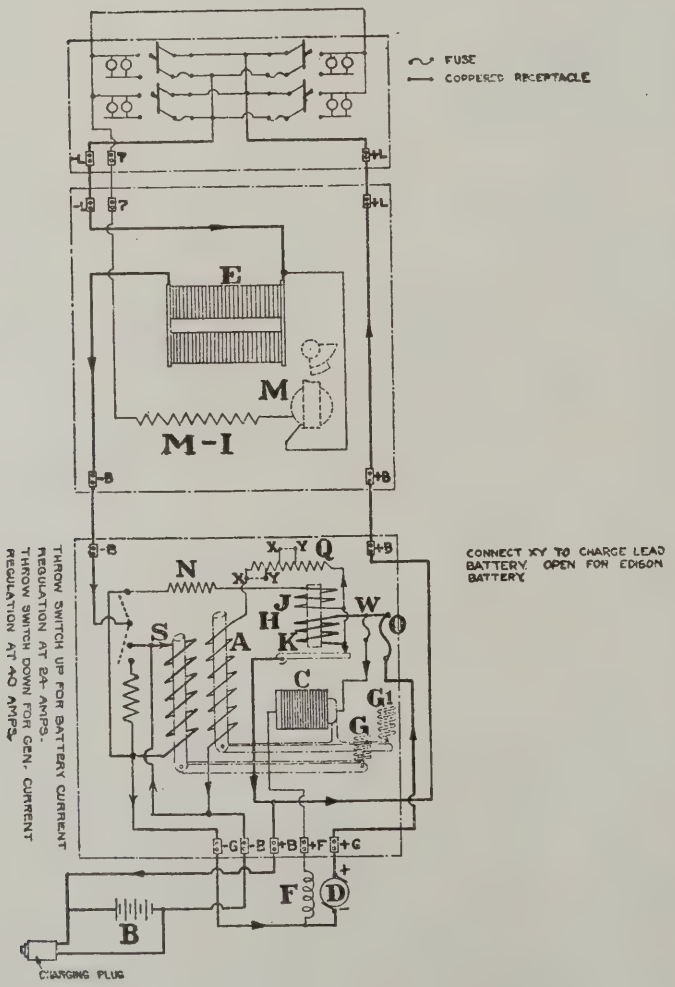


Fig. 4—Wiring Diagram Type F-2 Equipment

Suspension

The Type F2 Safety generator is suspended from the car body. The Safety or P. R. R. constant belt tension devices are used with this equipment. These devices have been also previously described.

Storage Battery

The storage battery used with the Type F2 Safety equipment consists of 25 Type A-4-H Edison cells. This battery is assembled in five trays, five cells per tray, and has a capacity of 150 ampere hours.

The lead storage battery may also be used with this equipment.

Operation

Fig. 4 is a wiring diagram of the Type F2 Safety equipment and the operation is as follows:

When the car is standing and the generator inoperative, the current to the lamps is furnished by the storage battery *B*. When the car is in motion, the generator voltage will build up due to the residual magnetism of

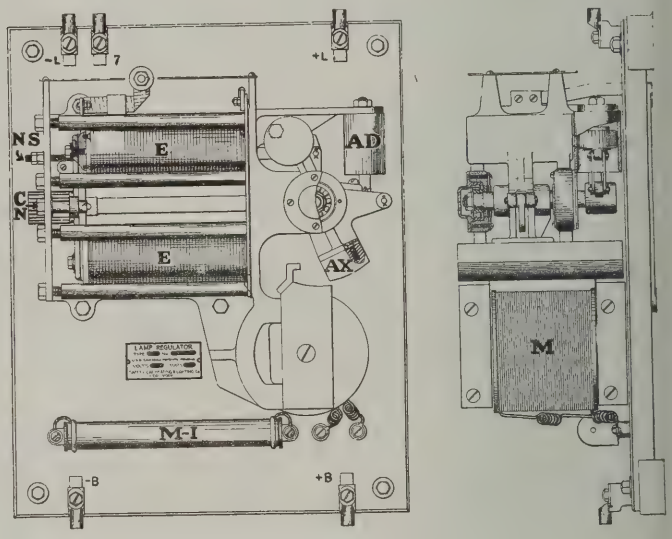


Fig. 5—Type F-2 Lamp Regulator

the field pole pieces. At slow speeds there is generated in the armature a low voltage which forces a small amount of current through three parallel circuits—the lifting coil *J* of the automatic switch, the field circuit *F*, and the voltage regulating coil *A*.

While the voltage regulating coil *A* circuit is alive at this time, it remains inoperative until the battery is fully charged. As the field of the armature is increased, and the current in the field circuit increases the field magnetism strength, the generator voltage also increases until it reaches 33 volts, at which time the automatic switch *H* should close and connect the generator to the car wiring.

The instant the automatic switch closes all circuits become energized, the machine furnishing the current for any lamps that may be turned on, but delivering only a small amount of current to the battery. As the speed increases the generator voltage rises, and the generator current increases until the current and voltage regulating devices go into operation. The generator regulator is what is known as the combination current and voltage type which produces a charging current that is constant until the battery is fully charged and then tapers off to

approximately 10 amperes. In addition to this, the regulator is designed so that it will either limit the battery charging current to 24 amperes independently of the lamp load or limit the total generator output to 41 amperes.

With the first method, known as "constant battery charging current with voltage control," 24 amperes will flow to the battery, providing the voltage coil does not come into action, and all lamp current will simply be

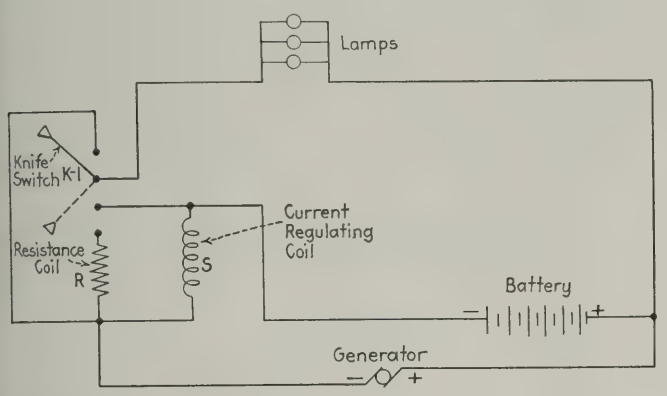


Fig. 6—Schematic Wiring Diagram of Main Circuits, Knife Switch Up for 24 Ampere Battery Charge; Knife Switch Down for 41 Ampere Generator Current

added to the generator load without affecting the amount of charging current. With the second method, "full generator output," a useful current of 41 amperes will be available, either for lamps, battery, or both. The change from one method of operation to the other is made by throwing the knife switch, *K*-1. The schematic diagram, Fig. 6, shows how the change in control is made.

When switch *K*-1 is up, the series coil *S* controls the

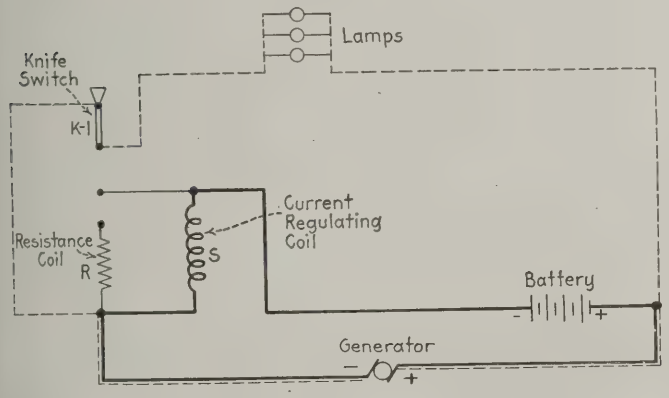


Fig. 7—Schematic Wiring Diagram of Main Circuits. Knife Switch Up for Constant Current of 24 Amperes to Battery. Heavy Line Shows Path of Charging Current from the Generator Through Battery and Current Regulating Coil, Back to Generator. The Path of the Lamp Current is Shown By Dotted Lines. Note that the Lamp Current is Direct From Generator to Lamps and Does Not Pass Through the Current Regulating Coil

battery charging current at 24 amperes. The lamp load is picked up by the generator because the negative lamp tap is made on the generator side of the series coil *S*, which means that no lamp current flows through that coil. This is further illustrated in Fig. 7. The path of the lamp current is shown by dotted lines, while that of the battery is shown by heavy lines.

When the knife-switch *K*-1 is down, as shown in Fig. 8, the negative side of the lamps is connected to the top of the coil *S* so that both lamp and battery current flows through the coil. But the knife-switch *K*-1 now also connects resistance *R* in parallel with the coil *S*, and this resistance is so designed that it allows a current of 17 amperes to shunt by the coil when 24 amperes are flow-

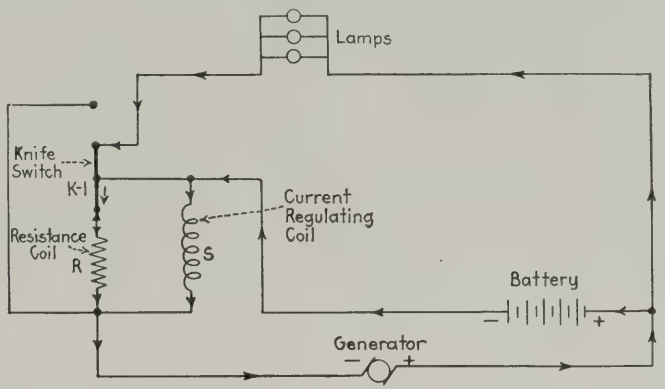


Fig. 8—Schematic Wiring Diagram of Main Circuits. Knife Switch in Down Position Generator Current Regulated to 41 Amperes and Current to Battery and Lamps is Shown By Arrows

ing through the coil itself. Therefore, the current which may flow through the multiple circuit of the series coil *S* and resistance coil *R* (sum of lamp and battery current) is now 41 amperes instead of 24 amperes, as is the case when the coil acts alone. This means that the maximum generator output, with knife-switch *K*-1 down, is 41 amperes, which is divided between battery and lamps, ac-

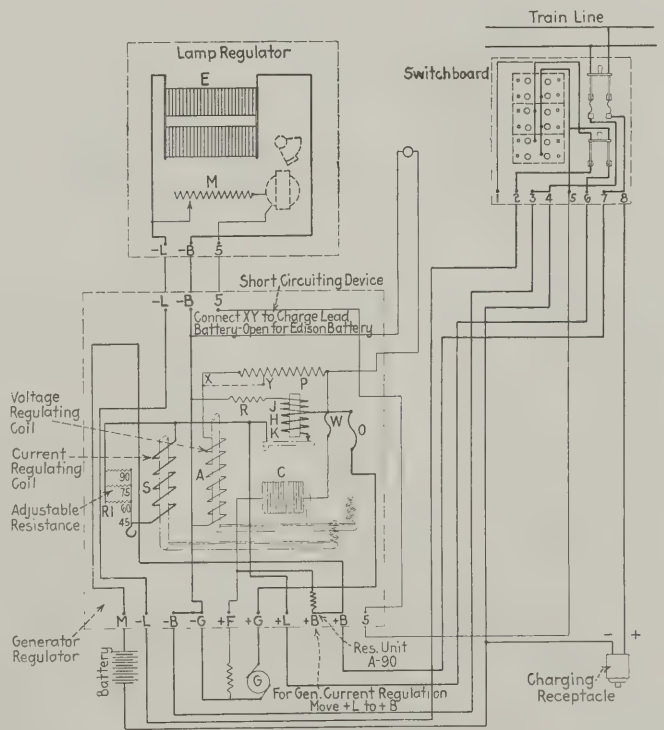


Fig. 9—Wiring Diagram of Type F Safety Equipment for the Pullman Company

cording to the number of lamps turned on and the battery condition. If all lamps are turned off, the entire generator output of 41 amperes is available for battery charging. This adjustment allows an extra heavy charging current in the winter and at other times when it is needed.

So far we have considered the current regulating fea-

ture of the generator regulator, which may be summed up as follows:

Knife-switch K-1 in up position.—The generator current will be the battery charging current of 24 amperes plus the lamp load. If the lamps are turned off, the total generator useful current will be 24 amperes. If the lamps are turned on and the lamp load is 17 amperes, the total generator useful current will be 24 ampere battery charge plus 17 ampere lamp load, or 41 amperes.

Knife-switch K-1 in down position.—The generator useful current will be 41 amperes. If the lights are turned off, the battery will receive a charging current of 41 amperes. If the lamps are turned on and the lamp load is 17 amperes, the total useful generator current will be 41 amperes, but the battery will receive the total generator useful current of 41 amperes, less the lamp load of 17 amperes, or 24 amperes.

The Type F2 generator regulator is a combination current and voltage type which produces a charging current that is constant until the battery is fully charged and then tapers off to approximately 10 amperes. Therefore, the above current regulation is only effective up to the point where the battery is fully charged and then the change is made from current to voltage regulation and the current to the battery will gradually taper to approximately 10 amperes.

The point of change from current to voltage regulation is governed by the setting of the voltage regulating coil *A*. If this coil is set to operate at 40 volts, the voltage coil will go into operation and hold the generator voltage constant at that amount.

The voltage regulating coil on the Type F2 generator regulator has four settings. As stated above, the *A* unit is provided with a short-circuiting device, which shunts out section *XY* of the unit. It was also stated that the upper end of the spring *G*-1 was attached to a slotted pin. This pin has three slots and the end of the spring may easily be placed in any one of the three slots.

When this equipment is used with the Type A-4-H 150 A. H. Edison battery, the short-circuiting device of the *Q* unit should be open, and closed when used with the lead battery.

The voltage setting when used with lead battery is 39 volts. This is made by closing the short-circuiting device and placing the spring *G*-1 in the top notch of the pin.

The voltage setting when used with the 150 ampere hour Edison battery is governed by the season of the year. The setting for summer is 43 volts, which is obtained by opening the short-circuiting device and placing the spring *G*-1 in the bottom notch.

The setting for spring or fall is changed to 45 volts by simply moving the spring *G*-1 to the middle notch. The setting for winter is changed to 47 volts by simply moving the spring *G*-1 to the top notch.

At this point the fact should be emphasized that these voltage settings are effective and that the control is changed from current to voltage at these respective voltages regardless of the position of the knife-switch *K*-1.

It is interesting to note that the normal charging rate of the Edison A-4-H battery is 30 amperes, and the regulated charging current, with the knife-switch *K*-1 up, is only 24 amperes, which is entirely satisfactory for this service.

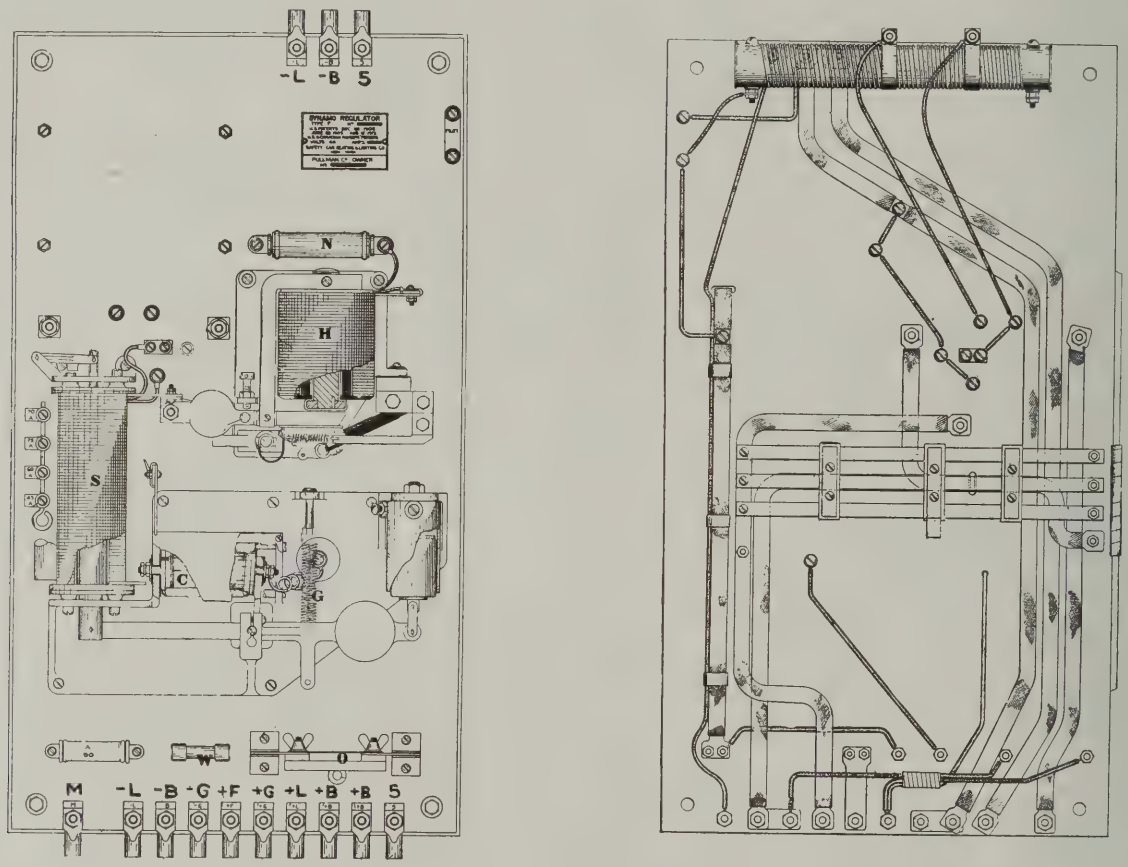


Fig. 10—Front and Back Connection of Generator Regulator Panel

Adjustments

The automatic switch is set by the manufacturer to close at 33 volts. No adjustment in service should be

necessary, but if it is found necessary to make an adjustment, this should be made at the stop at the left of the hinge pin; raising the stop makes the generator cut in at a higher voltage, and lowering it makes it cut in at a lower voltage. The position of the iron core should not be changed to make any adjustment, since, when properly set, the bottom of the core, contact block and top carbon block are all on the same horizontal line. This is necessary in order to insure that the copper brush will be drawn up solid so as to make a good wiping contact.

Generator Voltage Regulating Coil

The adjustment of this coil is set at the factory so that it regulates at 39 volts with lead batteries. When Edison batteries are used this voltage is raised to 43 volts by opening the short-circuiting device and 45 or 47 volts by moving the spring *G*-1 to their respective slots as just explained.

In order to check the setting of this voltage coil *A*, first be sure that no current is passing through the current coil *S*. This can be done by placing a sheet of insulating material between the contacts of the main switch, then no current is passing through the current coil, and the stop on its plunger rests against the top of the coil head. With the above conditions, the car running at a speed of 15 miles an hour or more, the voltage across the generator terminals on the regulator should be as given in the preceding paragraph. If the voltage is not correct it should be adjusted by the spring *G*-1. To check the setting of the current coil *S* connect an ammeter in the generator circuit. If the stop on the plunger guide of this current coil *S* is raised from the coil head, the coil is regulating and the ammeter will show at what current the coil is regulating. If the stop is against the coil head, compress the field carbons by hand through the voltage coil lever, and note the current at which the series coil plunger begins to rise. This is the current at which it will regulate, and should be within the rating of the dynamo.

The number of field carbons should be such that, when the car is standing, and the carbons are tightly compressed by the spring of the voltage solenoid, it is possible to slip a gage 1/64 in. thick between the projections on the levers of the voltage coil and series coil.

Lamp Regulator

To adjust the lamp regulator it is first necessary to get rid of all magnetism in the operating magnet, which can be accomplished by disconnecting the battery. Next, remove the air dash pot *AD*, Fig. 5, using special care not to injure the graphite plunger, leave the plunger hang loose on the arm and short circuit the two terminals marked —*L* and —*B* at the upper and lower left hand corners of the board, respectively. A piece of No. 12 copper wire makes a convenient jumper for short circuiting the two terminals. Next, unscrew the corrugated adjustment nut *CN*, Fig. 5, until the armature *AX* can be moved smoothly throughout its full arc of travel, then screw up very slowly on the adjusting nut *CN* until the armature *AX* will not quite go back against the top stop, after which the adjusting nut *CN* should again be unscrewed one-half turn and locked in this position by means of the clamping screw. The armature can now be moved through its complete arc of travel. To adjust the spring tension it is first necessary to get current on the panel and through the lamps, but without removing the short-circuiting jumper from the two terminals on the board. Then, with a voltmeter connected to the two mains of the lamp circuit, turn on or off the lamps until the instrument indicates 30 volts, at which time the tension of the spring should be so adjusted by nut *NS* that the armature will remain in any position throughout its stroke. It is important to maintain 30 volts at the lamps while adjusting the spring.

Next, remove the short-circuiting jumper, replace the dash pot, and note the lamp voltage as indicated on the voltmeter. If the drop across the carbon pile exceeds two volts, the carbons should be removed and the dust blown off the discs. If this does not reduce the drop, tighten up one or two notches on the adjusting nut *CN*. Next turn on all lamps and put the car on charge to obtain high voltage, and note the lamp voltage as indicated by the voltmeter. If it exceeds 32 volts the setting is incorrect and must be done over, or there is some defect in the regulator which should be corrected.

Type F Safety Equipment for the Pullman Company

The Type F Safety equipment for the Pullman Company was designed to meet with the Pullman specifications. It consists of a 4-kw. underframe generator, a generator regulator rated at 40 volts 100 amperes, a lamp regulator rated at 40 volts 50 amperes and a storage battery.

The general principle of operation is the same as that of the standard Type F equipment previously described, but the terminals on the regulators do not have the same location. It may also be noted by referring to the wiring diagram, Fig. 9, the addition of an adjustable resistance *R*, connected in multiple with the current regulating coil *S*. This adjustable resistance is provided with a sliding rod which shunts out sections of the resistance thereby changing the value of the current regulation to 45, 60, 75, or 90 amperes as desired. A 90-ohm. exciter unit has also been added, and located on the generator regulator panel.

The current regulation may be "current to battery." or "total generator current," depending upon the location of the lamp wire at the bottom of the generator regulator panel. The wire is connected to the $+L$ terminal for "battery current regulation," and to $+B$ terminal for "total generator current regulation."

The front and back connections of the generator regulator are shown in Fig. 10.

Space and connections have been provided on the front of the generator regulator panel for the mounting of an ampere-hour meter.

The program for Japan's government railways calls for an expenditure of $278,000,000 for new construction and $432,500,000 for improvements during the next ten years, according to the British Board of Trade Journal. During the past year some 200 miles of new line were built and during the present fiscal year it is estimated that an additional 260 miles will be built.

On January 1 of this year freight rates were increased by 28 per cent. The gross revenue for the fiscal year 1920 totaled some $102,500,000 from passenger traffic and $66,000,000 from freight traffic. Privately owned railways have increased greatly.

A Welded Locomotive Tender Tank

By J. W. Murphy
General Foreman, Boston & Albany, West Springfield, Mass.

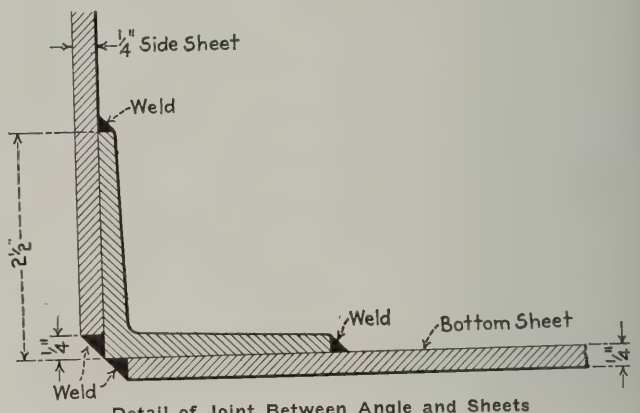
About six months ago, the Boston & Albany built at its West Springfield shops a tender tank of 8,000 gals. capacity, which was constructed entirely by welding the parts together by the electric arc process. So far as is known, this is the first departure from the customary riveted type construction for tender tanks.

Considerable experience had been gained with electric welding, particularly in boiler work, and in view of the successful results obtained and the adaptability of this process for welding seams of tanks, it was decided to construct a complete tank by electric arc welding. In the case of a riveted joint, considerable time is required for laying out and punching rivet holes and caulking. This work is not necessary in the case of electrically welded joints. Riveted joints cannot equal in strength the solid plate on account of the loss of metal at rivet holes, but welded joints if properly made have the strength of solid plate. It is recognized that the welded joint is strong and reliable and in the case of tank work there is the added advantage of freedom from leakage.

The electric welding process is superior to the oxy-acetylene process for certain kinds of work and as peculiarly adaptable for joining plates and welding seams. Oxy-acetylene welding can be used successfully in many kinds of repair work, but it is difficult to weld steel plates or sheets by this process on account of buckling and bulging produced by the heat.

The manner in which the sheets were welded to the tank angles is shown in the illustration. This is a satisfactory method, as the welding can be done readily at reasonable cost and the strength of the joint is in excess of that usually obtained by the riveted type of construction. The side plates are butt-welded and the tank braces and splash plates are afterwards securely welded to the side sheets. The whole construction results in a watertight tank of good appearance and great strength.

In assembling the various parts of the tank, approximately 1,200 linear feet of welding was done.

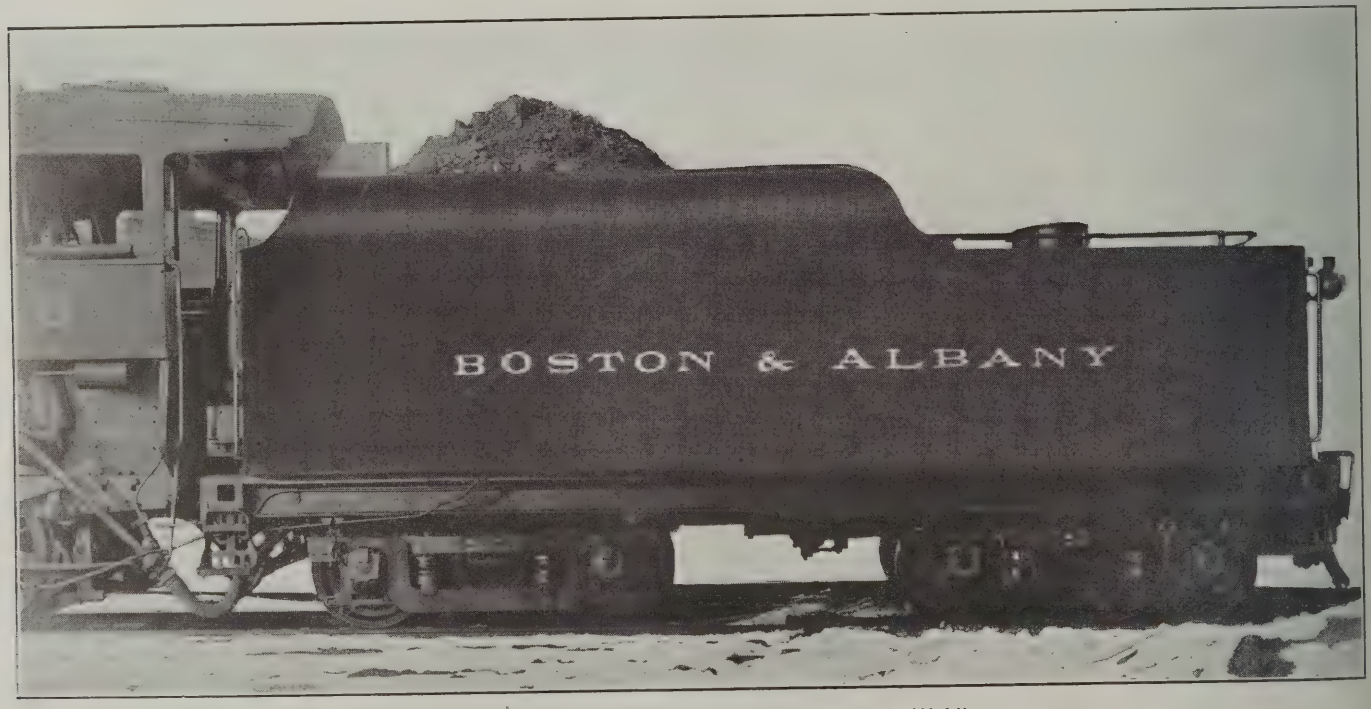


Detail of Joint Between Angle and Sheets

The following tabulation shows the welding work in detail:

Butt-welded seams ¼ in. plate	95 ft.
8 Reinforcing tees, 3½ in. by 3½ in. by ⅜ in.	550 ft.
10 Tank angles, 2½ in. by 2½ in. by 5/16 in.	410 ft.
23 Side tees, 3½ in. by 3½ in. by ⅜ in.	120 ft.
Beading at coal side	25 ft.
Total linear feet of welding	1,200 ft.

The safety appliances and tank lugs are riveted to the sheet. The completed tank is 26 ft. long, 10 ft. wide and 5 ft. 2 in. high, having a capacity of 8,000 gals. of water and 12 tons of coal. It is supported on a cast steel underframe and is used with a Pacific type locomotive in passenger service. The photograph shows the appearance of the completed tank, the absence of rivet heads being particularly noticeable.



All Seams in This Tender Were Joined by Electric Welding

The welded method of construction eliminates the necessity of punching rivet holes in sheets, tees and angles and there appears to be less likelihood of leaks developing in service.

The Protection of Metallic Arc Welds*

Inspection Methods Used in Determining Integrity of Joints; Coated Electrodes Insure Purity of Welding Metal

DETAILED description or instructions for any particular welding job or jobs must of necessity be handled in detail papers. However, it might be well to include a few words on weld inspection and weld records.

It is generally admitted that imperfect soundness of a weld structure is the most common cause of failure of a welded joint. A knowledge of the factors responsible for these imperfections in soundness and of the conditions necessary to eliminate their existence, leaves little or no excuse for their occurrence.

The factors responsible or contributory to unsound arc welds are: (1) poor fusion; (2) slag inclusions and (3) porosity. Of the different methods of inspection to determine the character of welds, the most practical are:

1. A visual examination to determine—
   (a) Appearance of weld surface as an index to workmanship.
   (b) Uniformity of deposit as an indication of faithfulness with which fused-in metal is placed in position and, therefore, ability to manipulate arc.
   (c) Existence of slag and presence of porosity as evidenced by appearance of deposit surface and uniformity of fusion between deposits.
   (d) When conditions permit, fusion of deposited metal to edges at bottom of "8" by inspection of reverse side of joint.

2. Chipping base of deposits with cold chisel to determine adhesion of deposit and ductility of fused-in metal. If the chipping breaks short, like a poor grade of cast iron, it is a fair indication that the metal is burned (oxidized), due to excessive heat or excessive arc length. Welds composed of such metal will break comparatively easy when subjected to transverse stresses.

3. Penetration test to detect linked gas pockets, slag pockets, porosity and unfused zones.

While there are a number of possible methods that may be used to detect such weld imperfections, the penetration test offers the most reliable indication of unsoundness extending through the weld section, isolated unfused zones, globule inclusions, gas pockets, etc., will of course not be detected by the penetration test.

Kerosene is a most effective liquid for this purpose and it is usually easy to obtain. When sprayed on one side of a welded joint, if there exists a chain of unfused zones, slag pockets, gas pockets, porosity, etc., through the weld section, the kerosene will be drawn into the capillaries produced by the imperfections and if these extend through the section, a stain will appear on the reverse side of the joint. This method will be found convenient and effective to determine whether or not a joint is leak proof to water, air, steam, oil, etc.

In addition to the visual examination of welds and penetration test, operators should check their aptitude by welding sample pieces of boiler plate together under conditions similar to those encountered in practice. By bending to a point of rupture and noting the angle of bend and the appearance and structure of the weld metal, fair evidence of the operator's ability to produce a sound weld will be given, and the nature of the defects found, if any, will be suggestive as to their cause. While it is quite possible for a weld to contain a number of small distributed imperfections without greatly affecting its quality, they should be eliminated to as great an extent as possible. Foremen should occasionally require operators to make tests of this nature in order that both may know the quality of the work that can be produced.

A further check may be made by submission of welded samples to an engineer of tests. To obtain tensile test, samples should conform to standard coupons.

It is probable that a record of all important welds is most easily made and maintained by using some such system as is employed on the Rock Island Lines, which consists of having the following record legibly stamped on the weld by at least ⅜ in. steel stencils in the following form:

E

(Mo. — Day — Yr.)	Railroad
(o — O — o)	A B C
Local shop symbol or shop abbreviation mark.	Welder identification number or mark.

Note: E. denotes electric weld.

In case of any industry other than a railroad, the name of manufacturer or firm should be substituted in place of the name of the railroad.

Some of the most recent developments include the use of high manganese for certain wheel flanges where wear is very excessive, also the splicing of center and side sills of steel under-frame for freight car, including draft gear support—all entirely arc welded without a rivet.

Some time ago we developed a diagonal strapped butt welded joint for high pressure and heavy loads, which is giving excellent service and promises to be extremely successful. All parts of this joint are similar to all other important welds, and practically all welds are important, at least in so far as railroads are concerned. All are carefully fitted with perfectly smooth surfaces provided for applying the added metal.

We are not attempting to show any statistics as regards individual savings, or economies effected, since this would require long drawn out mileage and service tables for various parts, with qualifying statements and description of far-reaching effect of indirect savings, necessary for intelligent comparison. However, we might well say that in checking our records last spring, we found that on an investment of $150,000 for electric arc welding equipment, we are realizing an annual net return of approximately 300 per cent. This figure will not hold for future and additional equipment, since we have already reached

*The second part of a paper presented before the Metropolitan Section of the American Welding Society by E. Wanamaker, electrical engineer of the Chicago, Rock Island & Pacific Railway.

the point where 40 to 50 per cent is all that might be possible in many instances, as we have about exhausted the jobs on which such tremendous savings can be made, and the only savings possible to effect will be the direct saving over some other process of manufacture or repair, the essence of time factor, etc., not being felt.

Just here it might be well to say that on the Rock Island Lines we have recently abandoned the use of all electrodes other than coated, experience having demonstrated that in so far as autogenous welding is concerned, the best is none too good, and this holds for welding equipments as well as for welding materials. This fact is especially noticeable when considering the comparatively low resistance fatigue of metals in cast forms.

In drawing up our general and detail welding instructions and specifications, we have this slogan constantly before us, "The best is none too good," and we include engineering, design, supervision and operation, as well as equipment and materials. Also, we have one other slogan which may be said to be secondary to the primary slogan, that in so far as autogenous welding is concerned, "Cleanliness is ahead of Godliness."

Viewing this art or process from a somewhat academic standpoint as well as from the standpoint of the technician or commercial user, we are forced to the conclusion that there are two general types or classes of autogenous welds—based on atmospheric interference, "the protected weld" and "the unprotected weld."

We are all familiar with the thermit and gas welding methods and the means taken to secure as far as possible "protected welds." Hence, since the scope of this paper is limited to the electric arc welding process, we will deal with protected and unprotected electric arc welds, which is in turn confined to the metallic arc process.

Our years of experience indicate that the metal passing from the end of the electrode into the weld is in a highly molten state, indeed a generous proportion of it in a gaseous state, and therefore extremely susceptible to atmospheric effects, even though the journey through the atmosphere is a short one. By the use of such coated electrodes as are used on the Rock Island Lines (and which it might be well to say, only developed after years of experience and patient research, laboratory and service tests), we were able, to a large degree, to eliminate this damaging effect. Indeed not only were we able to protect the iron and low carbon content steel electrodes, but to go further and protect the various alloys, the use of which is extremely desirable to meet certain conditions. Such alloys as tungsten, nickel, vanadium, chromium, molybdenum and manganese meeting some very necessarily important demands.

Electrodes to have any real value must be very carefully produced to meet the necessarily exacting specifications which in turn were only possible as a result of the combined prolonged efforts of those engaged in scientific research, development and application.

To produce such electrodes, much expense is incurred over and above the production of mere wire, but in no other way is it possible to produce the proper electrode with the proper welding characteristics for the job in hand and secure a "protected weld." Even so a comparison of high grade electrode costs compared with per pound prices of steel castings, high grade steel, etc. (long ago deemed necessary), causes one to marvel at the low electrode cost. It would seem reasonable to believe that we could no more secure good electric arc welds with poor or unsuitable welding material than we could expect to build machinery or structures out of poor or unsuitable materials.

In writing specifications, the section dealing with inspection and test, should give consideration not only to the tensile strength test, but also to impact and breathing test, repeated and alternate stresses, etc.

It is today possible to make very high tensile welds, but the consideration of this factor alone is not sufficient, especially when attention is called to the aging of iron and steel, and the effects of fatigue in connection therewith. The percentage of elongation obtained by some of the methods for testing welds is not a criterion—the elongation of the original stock depending to a large degree on the tensile strength of the added metal. However, in the great majority of engineering designs where autogenous welding is used, the elongation in itself is not such an important factor, provided the impact, breathing, repeated and alternate stress tests are sufficiently good to resist fatigue.

However, I feel that in considering the autogenous weld, we have been very weak in not considering carefully that factor known as fatigue. As one of the pioneers in autogenous welding, I might be able to present the following to you in such a manner as to prove of some interest.

When the railways first went to the cast steel truck side for car work, the primary object in the instance of freight car, was to get away from the failure of truck frames, due to the eventual cracking of arch bars at bolt holes, or at points where the arch bar has a gamber or angle formed to produce the arch section or structure. The elimination of bolts and their continual loosening, which either caused eventual truck failures, or required an excessive amount of labor for maintenance was also desired. Apparently the wrought iron or rolled steel bar, when of proper section, etc., was entirely satisfactory, except for the weakness as mentioned above. In other words, they were not easily affected by metal fatigue, the crystalline structure of wrought iron and rolled steel being such as to strongly resist the tendency to fatigue.

For somewhat similar reasons, the railways also began the use of cast steel truck and body bolsters. At about the same time the cast steel truck side came into use.

As the result of several years' close watching and checking, we find that the cast metal is much more liable to fatigue than is the wrought iron or rolled steel. For instance, the bolsters and truck sides, for an average of say five years, stand up successfully. However, at about the sixth year, they begin to crack and fracture due to fatigue.

We have found that where the manufacturer has been careful to prevent, as far as possible, the atmospheric effects when the casting was being poured, and to eliminate contraction strains by subsequent annealing, better material was secured with reduced liability to fatigue and failure. Also when this fact is recognized, and the proper sections and distribution of the metal used in the casting, that the life can be greatly extended. In fact, today we are repairing these defective bolsters and truck sides by reinforcing the entire weak section by using a wrought iron or rolled steel part of sufficient strength to meet the demands, same being applied by the electric arc welding process, using coated electrodes to lessen the atmospheric effect, and to minimize contraction strains by prolonged cooling incidental to the coating, the equipment having the proper welding characteristics. The entire job is then thoroughly annealed in order to restore the physical condition of the member that has been repaired, and also to reduce any thermal effects that may have been produced by the localized heat in welding.

Inasmuch as the autogenous welds (referring primarily to electric arc and gas) are metal in cast form, it seems to me in drawing specifications, we should continually bear in mind the effects of fatigue and locked-in or contraction strains and stresses since it is evident that fatigue much more quickly affects cast steel than it does wrought iron or rolled steel. For instance, fatigue may not effect the wrought iron or rolled steel material in less than thirty years, while it might affect the cast steel, such as is in an autogenous weld, in approximately six years; that is, based on our truck side and bolster experience. However, the vibration of truck sides and bolsters is heavier and more severe on account of the impact, repeating and reversing stresses set up in them due to the continuous pounding, jolting and jarring over the tracks, than would be, for instance, in boilers. In boiler work we do have the vibration and fatigue, and it would seem it would take a much longer period of time for the effects to accumulate sufficiently to show. For instance, a low pressure boiler, say with a 15 lb. pressure limit, if designed and welded under proper specifications, may not show any of the effects of fatigue for 15 or 20 years, and then at that time show fractures or cracks such as would probably cause leaks and which might also mean a failure of the vessel. If, however, steps are taken to prevent as far as possible atmospheric interference with the metal placed in the weld, it is very probable that this trouble would never occur. You will probably note that I am endeavoring to look far into the future, and the time element is a very important factor for consideration.

In the welding of unfired pressure vessels, say to 125 or 150 lb. limit of pressure, it would seem that the consideration of fatigue should be given the same careful study and attention as the fired vessel. It is true that in a fired low pressure vessel, we have in addition to the vibrations, the movement due to expansion and contraction, caused by the alternate heating and cooling effects. In the unfired vessel we have in many cases far more vibration, with a pressure far more apt to cause rupture which may or may not be disastrous, and the specifications for unfired pressure vessels with a limit of 150 lb. should be given, to say the least, as much careful consideration as the fired pressure vessel with a 15 lb. pressure limit.

The recent study and survey would, to say the least, seem to indicate the necessity for all regulatory bodies drawing rigid specifications to govern autogenous welding in all cases where failure might cause loss of life or heavy property loss.

These specifications should be prepared by or through the conjunctive work of all interested regulatory bodies, including insurance bodies—that is, those having to do with boiler construction including buildings, edifices and structures, railroads, vehicles, etc.

This job is of some magnitude, but it is not as difficult as would seem at first notice, for we are today in possession of sufficient facts and data to enable us to draw up specifications covering certain ranges or limitations allowable at the present time, and from year to year, or from period to period, this range or limit can be extended, as improved and increasing facilities permit. These specifications could probably best be prepared and issued in book form sub-divided into various sections.

The code developed for boilers by the American Society of Mechanical Engineers and the code for electrical work as developed by the National Board of Fire Underwriters, might well serve as guides or examples in preparing these specifications. The specifications of necessity should fully cover the three prime requisites, so that none but the proper equipment and the proper materials for the job in hand be acceptable—material, including the original material to be welded and the welding material to be applied in the weld, there being a certain correlation between the two. Likewise, the permissible methods, including engineering, supervision, and operation, should be fully specified in detail. These specifications can be placed in universal service by federal, state and municipal governments, as well as by all other regulatory bodies.

In closing, the author must seek pardon for not including a mass of detail as to how various welding jobs are to be performed, as he knows that these questions are constantly arising. He feels, however, that it would not be good business to waste valuable time in an endeavor to present such data and information in an unorganized mass, as will only be possible until such time as some initial general instructions and specifications are made standard. He feels that a great loss has accrued to the electric arc welding industry because this has not been done, and he again repeats that he deems it vital and necessary that all those interested now join together in developing a set of general specifications in order that the detailed specifications may follow.

It would seem that this is the foundation of the entire instructive and governing structure which must be erected before the electric arc welding process can achieve the universal use which it deserves. A superstructure consisting of detailed instructions and specifications can then easily be erected on the completed foundation.

This method of procedure is along the line of a commercial or business organization and development, and the author feels that this is the time (and a most opportune time) for all who are interested in the electric welding art and the economic prospects and welfare of our country, to unite, in order that our combined efforts be utilized in speedily reaching the desired goal of ultimate success.

Methods and Devices Used by The Pullman Company

Shop Tools and Practices Which Speed Up and Simplify Car Lighting Maintenance Work

Part 2*

THE car lighting maintenance work done by The Pullman Company is necessarily more elaborate than that done by individual railroads, the principal repair shops are larger, and as a result more labor saving devices can be developed and used economically. The devices described in this article are used in the Pullman electrical repair shop at Buffalo, N. Y., and while some of them may not be suitable for the average railroad shop,

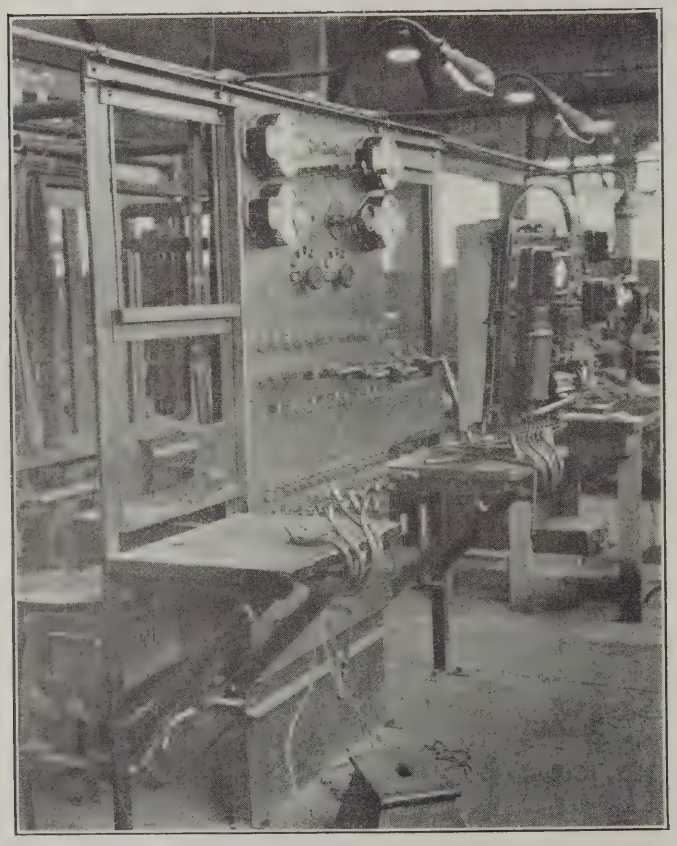


Fig. 1—Generator Regulator Testing Switchboard

there are among them others that could be adopted to good advantage. The general lay-out of the shop was shown in Part 1 of this article which appeared in the September issue.

With the possible exception of the regulator and meter testing switchboards, practically all of the tools were developed from such material as is available from time to time in any railroad shop.

*Part 1 was published in the September issue of the *Railway Electrical Engineer* and described lead storage battery maintenance and the construction of a new type of cell.

Regulator and Meter Testing

Three separate switchboards shown in Figs. 1, 2 and 3 are provided for the testing of generator regulators, lamp regulators and ampere hour meters, respectively.

Two generator regulator panels can be tested at a time. The panels are brought into the shop from the car and clamped into metal frame. There are pins in the bottom of the frames which fit into sockets located on either side of the switchboard, Fig. 1. The

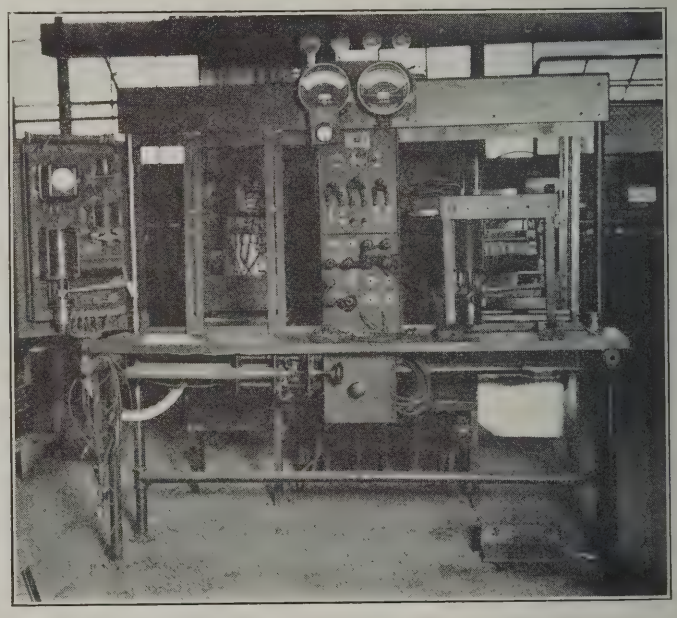


Fig. 2—Lamp Regulator Testing Switchboard

wires shown at the left are then fastened to the binding posts and the regulator is ready for testing. One of the regulators thus connected is shown at the right. A car lighting generator, belt driven by a variable speed motor, supplies the power for testing and allows the operator to create conditions similar to those under which the equipment must operate on the road.

Two lamp regulators can be tested simultaneously in a similar manner, a carbon pile resistance being used to take the place of the lamp load. The manner in which lamp regulators are overhauled and tested is described later in this article. The ampere hour meters are tested

by connecting them in series with and comparing them with a standard meter.

A Bench for Pipe Work

A shop tool which was made when the old shop was replaced by the new one is shown in Fig. 4. An old line shaft hanger forms a substantial standard at one end and a piece of 1½-in. pipe supports the other end of the heavy sheet metal top. The edge of the top is flanged to keep tools, pipe fittings and short lengths of pipe on the bench from falling off. A brace which extends from the under side of the bench top to a point near the center of the hanger gives the bench strength longitudinally. The bench top is about 30 in. high and the vise is mounted on a wood block which raises it 8 in. above the top and places the pipe at a height convenient to the use of a stock and die, pipe cutter or hack saw. A rear support for the pipe is placed about 30 in. back of the vise jaws made

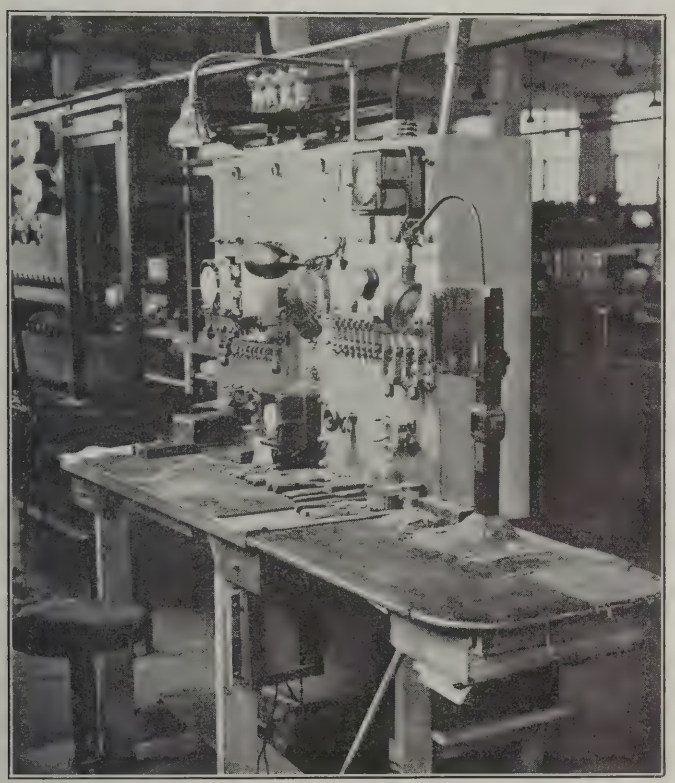


Fig. 3—Ampere Hour Meter Testing Switchboard

from two pieces of strap iron and a grooved wheel, similar to the smaller wheels used to support the pipe lines of interlocking plants. When the pipe in the vise is shorter than 30 in., no rear support is necessary.

A Pipe Bending Machine

Line shaft hangers are also used to support the pipe bending machine shown in Fig. 5. The 16-inch air cylinder which supplies the power is controlled from any position by the foot treadle or by the hand lever shown at the right.

Either the hand lever or the treadle rotates a shaft made of a piece of iron rod which extends from one end of the machine to the other under the bending table. At the end of the rod opposite the handle a grooved wheel is mounted. A piece of steel cable is wound in the groove and the free end of the cable supports an iron weight which can be seen below the cylinder at the left. The same grooved wheel is connected by a crank pin and set of levers to the inlet and exhaust levers, also shown at the left. When the treadle is depressed the exhaust valve is closed, the inlet valve opened and the cable wound on the grooved pulley. This causes the piston to move forward. When the pressure on the treadle is released slightly, the weight

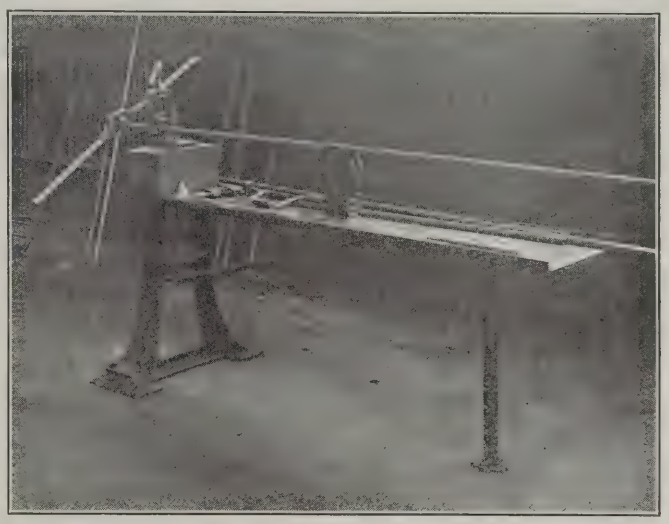


Fig. 4—A Bench for Pipe Work

reverses the rotation of the grooved pulley which in turn closes the air inlet. This stops the motion of the piston. When the treadle is released further, the exhaust valve opens and the spring in the air cylinder pushes the piston all the way back.

This pipe bender is used successfully for all sizes of

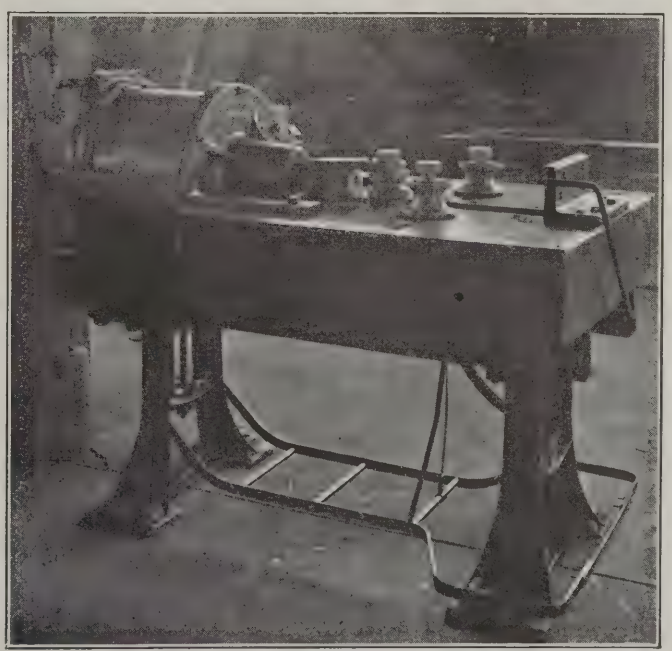


Fig. 5—Air Operated Pipe Bending Machine With Foot or Hand Control

pipe up to 2½ in. Various sizes of rollers are used on the clevis at the outer end of the piston and for the larger sizes of pipe it has been found necessary to use a grooved casting which cannot turn in the clevis in the place of the roller.

Direct Driven Grinder

The grinder shown in Fig. 6, like the pipe bending machine, is supported by two line shaft hangers and consists principally of a Bliss-Bucker car lighting generator. The two armatures are connected in series and both operate as motors on the 125-volt direct current power supply with which the shop is furnished. A grinding wheel is mounted on each end of the shaft. There is a rest for the work in front of each wheel, a guard at the back and a piece of heavy plate glass, held in a metal frame, at the top protect the eyes of the operator from flying particles without interfering with his view of the work. The square can at the front of the cable contains water for cooling the work. This machine has a large amount of reserve power and the heaviest work will scarcely reduce the speed perceptibly.

A Shaft Remover

Armatures keyed to shafts are usually taken off the shaft by bringing one end of the shaft down on the wood

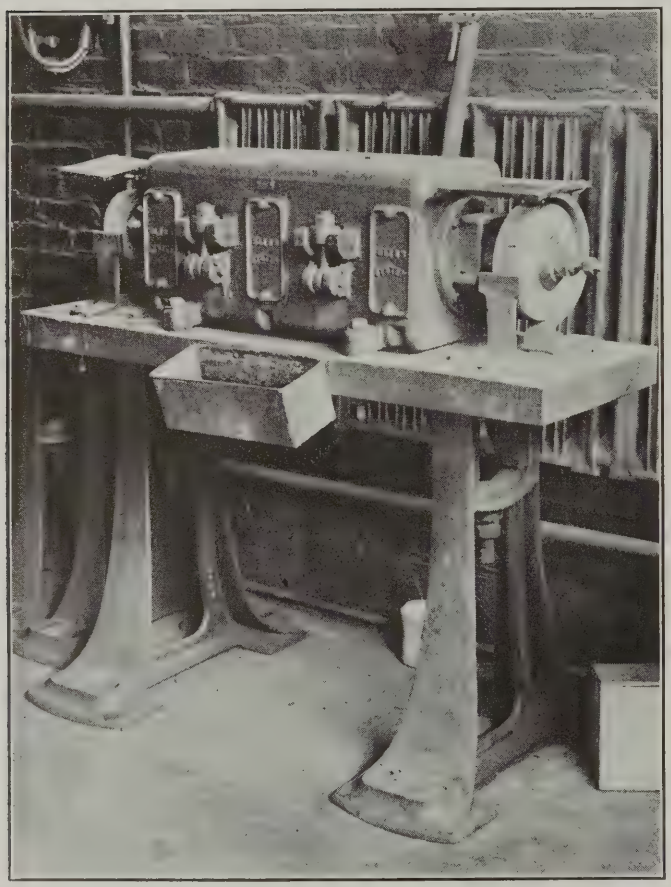


Fig. 6—A Grinding Machine Made From a Bliss-Bucker Car Lighting Generator

or lead block. This is severe treatment for the block and does not always make the removal of the shaft as easy as is desirable.

A device for this purpose is shown in Fig. 7. It is made of an old generator frame, concrete and lead. The frame is laid on its side and filled to within two inches of the top with concrete. When the concrete has hardened the remainder of the frame is filled with lead. This affords a bumping block which is high enough to make the work easy and one that will last indefinitely. In cases where generator frames were not available for this purpose, sections of pipe of approximately the same diameter have been used with equally satisfactory results.

Armature Repairs

The section of the shop in which armatures are repaired is shown in Fig. 8. In the foreground is one of the racks used for supporting the armatures while they are being rewound or are undergoing repairs. The end columns which are notched to receive the armature shaft, can be raised or lowered to any height convenient to the op-

Fig. 7—A Device for Removing Armature Shafts

erator. A piece of pipe at one end is used as a hanger for new coils and a convenient tray at the other makes a place for tools and small repair parts. Both the pipe and the tray are hinged so that they can be swung back and forth to the most convenient position.

A Coil Winding Machine

A coil winding machine which represents a considerable amount of development work is shown in Fig. 9. The reels at the left hold the wire for the coils and the blocks

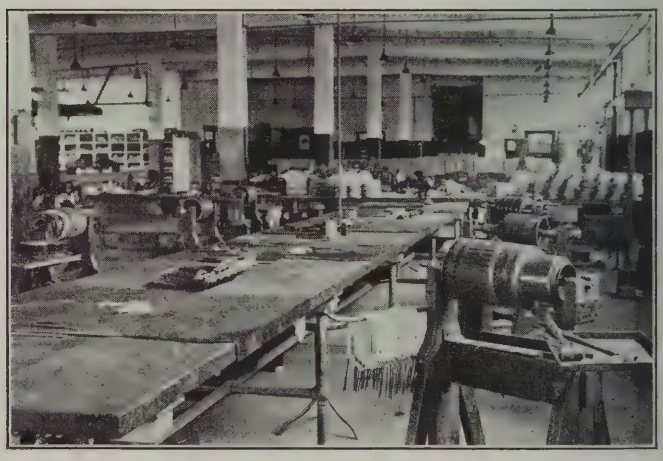


Fig. 8—The Section of the Shop in Which Armatures are Repaired

bolted to the floor provide a proper winding tension. These blocks are lined with pieces of smooth fibre, such as is used for slot insulation, and this makes it possible to secure the required tension without injuring the insulation on the wire.

The machine itself is mounted on a low table and consists of a short piece of shafting mounted on two bearings

and equipped with a small pulley and a coil winding form at one end of the shaft. A short piece of belting is stretched over the pulley with the end away from the reels securely fastened to the table and the end toward the reels held taut by a helical spring underneath the table. The belt and pulley are the equivalent of a pawl and ratchet wheel with an infinite number of notches. The wheel can

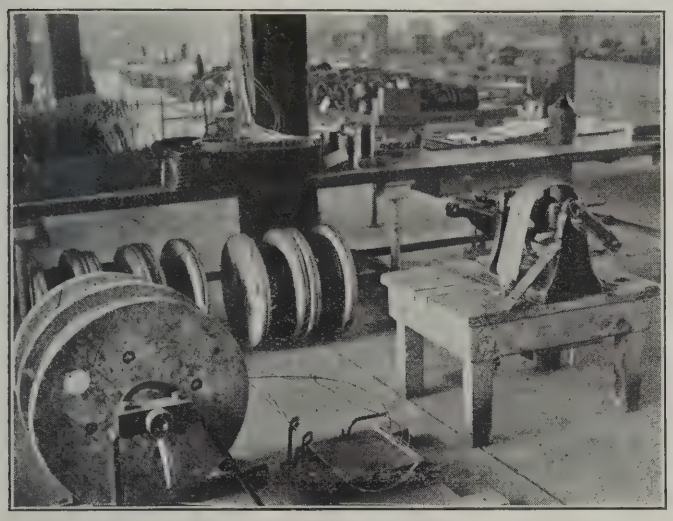


Fig. 9—A Device for Winding Armature Coils

be rotated to the right easily, but a great amount of force would be required to turn it to the left.

The winding form at the forward end of the shaft is so shaped as to hold the right amount of wire for the coil, and the face plate shown leaning against one of the bearing supports holds the wire in place while the coil is being wound. Bolts through the form fitted with wing nuts

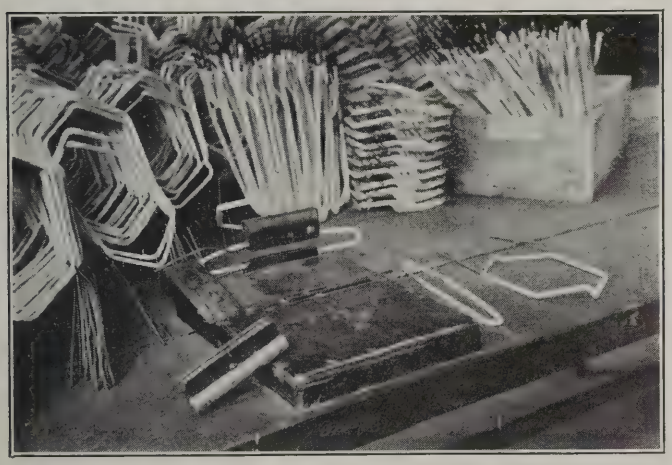


Fig. 10—An Extremely Simple Type of Coil Forming Device

hold the face plate in position and make it easy to take the face plate off for removing the coil when it is wound.

Coil Forming Device

After the coils are wound they are taped and placed on a bench ready for forming. The forming device, shown in Fig. 10, is extremely simple. It consists principally of a piece of board covered with fibre with a grooved slot at one end.

The coil to be formed is placed in the grooved slot in the position shown with one end against the stop block at the left. Another grooved slot with a handle is placed over the top of the coil and is drawn down to the surface of the board and forward to the small stop at the centre. This simple operation forms the coil. A coil before forming and another after forming are shown at the right.

Dipping and Drying Rack

A dipping and drying rack for armature coils is shown in Fig. 11. The square tank at the front underneath the trough is filled with baking varnish and after the coils are formed they are dipped in this tank and hung up on the rod above until the excess varnish has drained off. The varnish dripping from the coils runs down the steep metal incline to the trough and back into the tank. As it was found difficult to keep the incline clean, a large sheet of wrapping paper is laid over it each time the coils are dipped. Spring brass clips grip the upper edge of the paper and hold it in place. The rods on which the coils are hung can be slipped out of the socket which supports them, and after the coils have drained sufficiently this is done and the coils are carried into the drying oven,

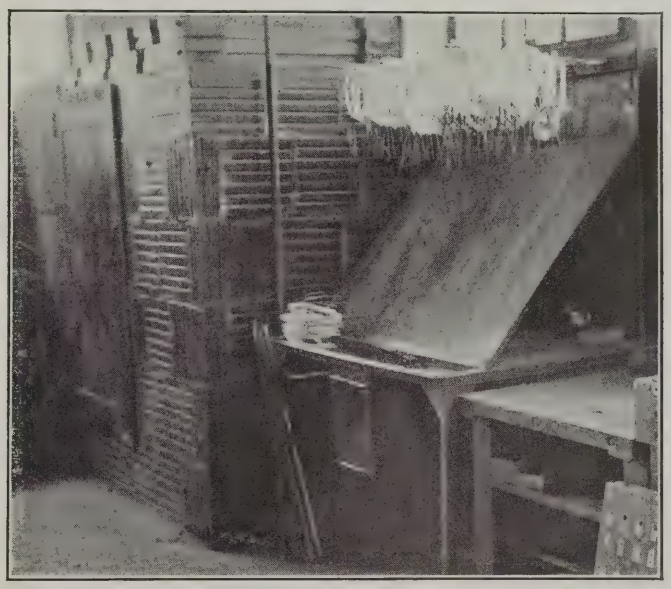


Fig. 11—A Dipping and Drying Rack and Baking Oven

shown back of the rack. In the oven the rods are fitted into similar sockets and the coils baked ready for placing in the armature slots.

Overhauling and Repairing Lamp Regulators

The method for overhauling and testing lamp regulators is thorough and involves the use of a number of kinks which have been developed in the Pullman shop and incorporated in the regular method of procedure. The substance of the following paragraphs was taken from a letter written by G. L. English, foreman electrician of the Buffalo shop, in which he outlines the procedure for testing U. S. L. lamp regulators:

Stripping and Cleaning

The CCO coil or type K relay, as it may be, should be removed, tagged and kept with the type B regulator. This avoids confusion and loss of time.

Remove the carbon pile and place it in a suitable rack or box where it will not be damaged until it is time to give it the necessary special treatment, described later. Remove the carbon pile lever, auxiliary lever and upper

plungers. The plungers with a tapered end and a graphite disc for top guide require no coil spring to overcome sticking or freezing, but others which have a square end require a short spiral spring and brass washer. The plunger should be re-coppered. To keep the spring and washer from being lost or misplaced, leave them on the piston stem, applying a small nut to the end of the stem to keep them from coming off. The thrust plate carbon should be removed, the surface on each side made true and level and then copper plated. Special care should be exercised to get a good plating on the side next to the thrust plate.

The right and left hand carbon contact disc should be removed and carefully inspected. Care should be exercised in seeing that the thrust plates are clean and that the carbon contact discs are trued and copper plated. The retaining screws in the disc should be countersunk below the surface so that the screw will not make contact with the adjacent disc.

Repairs

The flexible lead should be securely fastened to the thrust plate and arranged so that the movement of the plate will not be retarded.

Where thin copper strip leads are found they should be removed, a ¾-in. hole drilled through the centre of the slate panel and in line with the thrust plate, and a connector made from copper braided cable 6 in. long connected to the plate brought down through the hole and attached to the terminal post. This braided cable then forms a loop which allows perfect action in the thrust plate, and can be made from discarded generator pole changer leads, with the centre braiding pulled out. A good lug for the ends of this cable is made from the leaves of a scrap automatic switch contact. To do this cut strips ½ in. wide and long enough to go around the flat cable, forming a lug about 9/16 in. wide. Solder the tips and punch or drill the necessary holes.

Assembling

In applying the auxiliary lever see that the rollers work freely and are not out of round.

In replacing the plunger see that the piston stem is not sprung. Roll the plunger back and forth on a smooth level surface and if the stem is bent it will be noticed easily. Cams should be trued-up in a lathe.

In replacing the square end plunger, the thin brass washer must be placed next to the top plunger and the small spiral spring next to the washer. Care must be taken to see that the carbon pile lever is not sprung or out of line above the plunger.

Dash pots should be wiped out carefully with a little gasoline so that no gummy ridges or spots are left. The piston should also be cleaned carefully, but sandpaper must not be used for this purpose. In some instances it may be found that the air dash pot has been filled with oil. In these cases the graphite piston is destroyed and should be replaced with a new one. In cleaning the dash pot it is well to remove the air vent to make sure that it is clean. In completing the assembling make sure that all working parts are free.

The Care of Carbon Discs

Care of the discs used in the carbon piles is of first importance. It will be found that new carbon discs, as well as those which have been in use, are often more or less warped. It is impossible for a lamp regulator to work properly with discs in this condition.

In order to detect defective carbon discs, hold a stack of about twenty-five discs between the thumb and fingers toward the light with the stack in a vertical position. By moving the stack up and down it will be possible to see light between the discs at various places. When light can be seen in this manner the discs are in need of treatment.

A flat piece of steel or cast iron with a planed surface, such as is shown in Fig. 12, and a little No. 100 carborundum will suffice to put the discs back into good condition.

The procedure for re-surfacing the discs should be as follows: Pour a little of the carborundum on the flat

Fig. 12—Facilities for Reconditioning Carbon Discs

iron surface and move the disc over the carborundum in a circle, holding the disc down with the forefinger in the center and using the thumb and second finger at the edge. Press lightly with the forefinger, use the thumb and second finger to turn the disc around and at the same time continue to move the disc about on the plate in about a 7-in. circle. This method quickly grinds a true flat surface on the disc. Use a one-inch plater's brush to clean the surface of the disc. The use of the brush makes it possible to detect soft spots. A carbon pile with large soft spots will cause much trouble in the lamp regulator as the current will heat and burn the soft carbon and the reduced contact surface will finally cause the good carbon to burn also. It is, therefore, essential to use the brush freely for inspecting the surface of the disc. Wiping the disc off with rags or waste is bad practice, as it will hide the soft spots.

In applying the carbon discs to the regulator, see that lava tubes or porcelain bottom supports are used. They are more satisfactory than the asbestos tubes because they are smoother and do not affect the movement of the discs and will not shed small particles that can get into the plates. The asbestos tubes are entirely satisfactory for use as top retainers.

Old carbon discs that are serviceable can be placed at the left end of the carbon pile. but new carbon should be used at the right hand end. It is good practice to make up about one-half or one-third of the pile with new carbon. Copper plating should be ground off the face of the contact carbon disc. This can be done on the surfacing block that is used for truing the carbon disc.

Adjusting and Testing

A lamp regulator testing rack should be so arranged as to provide for the use of instruments, a battery and a generator regulator. Some of the type B regulators operate with a type K relay, and in these cases the type K relay should be carefully tested for grounds as the top housing or carbon pile cover is grounded in acting as a conductor for the top contact to the small carbon pile. It is important to see that the top carbon disc is clean.

When making adjustments it is good practice to start with the carbon pile adjusting screw on top of the relay. Turn this screw down until the contact very slightly compresses the carbon pile or until a slight cushion is felt in the carbon pile by pressing the plunger up and down. The lever adjustment is made by turning the brass tube to the right and left. This setting obtains the normal pressure on the pile and this pressure should be such that when normal voltage is applied to the coils, the resistance of the carbon pile is just sufficient to allow correct current to pass through the carbon pile and the solenoid of the lamp regulator, which is so adjusted that the correct pressure is extended on the carbon pile of the lamp regulator.

In adjusting type B lamp regulators there are six important points to consider as follows:

1. See that the regulator is clear from grounds.

2. Set the spring adjustment so that there will be about the normal pull on the carbon pile lever.

3. Release the auxiliary lever adjusting screw and when completely released commence to turn back with the left hand on the lever above the plunger. Pull up and down slightly on the lever and at the same time turn the adjusting screw until there is a slight pressure on the carbon pile with the smallest amount of down pull on the lever. Before locking the adjusting screw see that the lever cannot be pushed up more than about one-eighth inch from the point at which compression on the disc is started.

4. Connect in a battery with a no load potential of 33 volts, also a lamp load of 40 amperes and turn the spring setting until a potential of 31 volts on the load side of the regulator is obtained.

5. By a generator or other source of direct current supply, apply 40 or 45 volts to the regulator with a 40 ampere lamp load. Adjust the regulator to maintain the lamp voltage at 31, and then adjust so that the difference between battery and generator voltage is divided, getting the drop in the regulator as low as possible. When a regulator has been set with a type K relay, that relay should be kept with the regulator.

6. Regulators with a CCO coil have no coils or resistance units on back of the slate panel. The CCO coil controls the type B regulator potential coil in the same manner as the type K relay, excepting that there is no adjustment for the battery current. In the case of regulators with the CCO coil, the adjustment is made with the adjustable band near the centre of the coil which is connected to the generator positive. The band should be adjusted so that the smallest possible amount of voltage drop is obtained with the lamp voltage at 31 volts and a lamp load of from 38 to 40 amperes. Then apply an impressed voltage of 45 volts with a 40 ampere lamp load and move the band on the CCO coil or adjust the spring on the regulator, as may be required, until the voltage on the lamps is just 31 volts. This completes the necessary testing requirements, and if all of them can be complied with, the regulator is ready for replacement in service.

The Gas-Filled Incandescent Lamp

In a short research narrative recently written by Dr. Irving Langmuir, research laboratory, General Electric Company, he tells of the interesting development of the incandescent lamp as follows:

"Since 1879, when Edison gave the world the incandescent lamp, men have been working to improve this carbon filament vacuum light. A better filament was desired. Research produced tungsten filaments, a metal so rare as to be almost a curiosity.

"The use of tungsten as a filament did not solve all the lamp manufacturers' problems, although some electrical men held that with the development of wrought tungsten, lamp development had gone its limit. However, the lamp was far from perfect. A further reduction in the consumption of current was still desired and bulb blackening, which began as soon as the current was turned on, impaired the lamp's lighting power. All sorts of remedies were tried with little success.

"Scientists in the research laboratory at Schenectady undertook a number of fundamental investigations and it was not until three-fourths of the preliminary work had been done on a purely scientific basis that the real commercial usefulness of the results became apparent.

"Brittleness of the filament having been overcome by the development of wrought tungsten, the necessity for preventing bulb blackening still remained.

"Investigations along the lines of better vacua in lamps showed it was impracticable to determine whether variations in method or amount of exhaustion caused improvement. So studies were made along two lines: 1. The sources of gas within a lamp; 2, the effects produced in lamps by various gases.

"Research showed that the small amounts of water vapor present in the bulb greatly hastened blackening. The vapor oxidized the tungsten, freeing hydrogen in the atomic state. The oxide went to the bulb and was there reduced to metallic tungsten by the active hydrogen, releasing the oxygen which reunited with the hydrogen to form water. Thus the vicious cycle recurred until the lamp's life was ended.

"Early experimenters, Edison among them, had made numerous trials of a gas-filled bulb but in every case the experimental gas-filled lamp was decidedly inferior to the vacuum carbon lamp then in use. However, experiments showed that if a tungsten filament were heated close to its melting point in a gas-filled bulb entirely freed from water vapor, the filament lasted much longer than when heated in a vacuum, and the heavier the gas used, the more the evaporation of the metal was retarded. But the addition of the gas to increase the life of the filament meant an additional heat loss.

"It was found, however, that the presence of a dense gas, such as nitrogen or the hitherto unused argon, in the bulb, reduced the rate of filament evaporation to about one per cent of what it was in a vacuum at the same temperature. The convection currents in the gas carried the deposit of tungsten nitride to the top of the lamp, where it interfered little with the lamp's lighting powers.

"By using a large filament, or a coil of small filament, the heat loss was overcome by the higher temperature, and better, whiter light was produced.

"Thus, through careful research we have today a lamp far superior to the early incandescent light."

A New Electrically Driven Car Wheel Lathe

Unique Control Provides Slowdown and Stop Features of Benefit in Turning Wheel with Hard Spots

A NEW electrically driven car wheel lathe, together with the auxiliary electrical power supply and control equiment, was recently installed at the Fifty-first Street shop of the Chicago & Western Indiana at Chicago. The shop is operated in conjunction with a large coach yard and the majority of wheels handled are for passenger equipment.

The lathe is driven by a 50-hp., 220-volt, d. c. Westinghouse motor mounted beneath the floor level. A 5-hp., 220-volt, d. c. motor is used to operate the device for hoisting the wheels and axle into the proper position. The field control panel or cabinet is mounted on the wall behind the operator, the field rheostat is suspended above it from the ceiling and access to the rear of the panel is provided by a hole in the wall.

In truing up the tread and flanges of car wheels flat and hard spots are frequently encountered and to minimize the danger of breaking a tool when cutting through a hard spot, provision is made for reducing the cutting speed quickly. In case a tool is broken, the lathe can be reversed and the tool backed out and removed from the tool holder. To take care of wheels of different diameter and to obtain the correct cutting speed at the tool, speed control is provided.

The several circuits, push buttons and switches that accomplish these starts, stops, slowdowns and reversals are outlined in the circuit diagram shown in the sketch. The push button station shown at the left of the sketch is located on the main frame of the lathe immediately in front of the operator.

Having pushed the start button, the motor is started through three steps of acceleration by means of resistors cut out by automatic switches, thus reducing the strain on the tool at starting or after having been

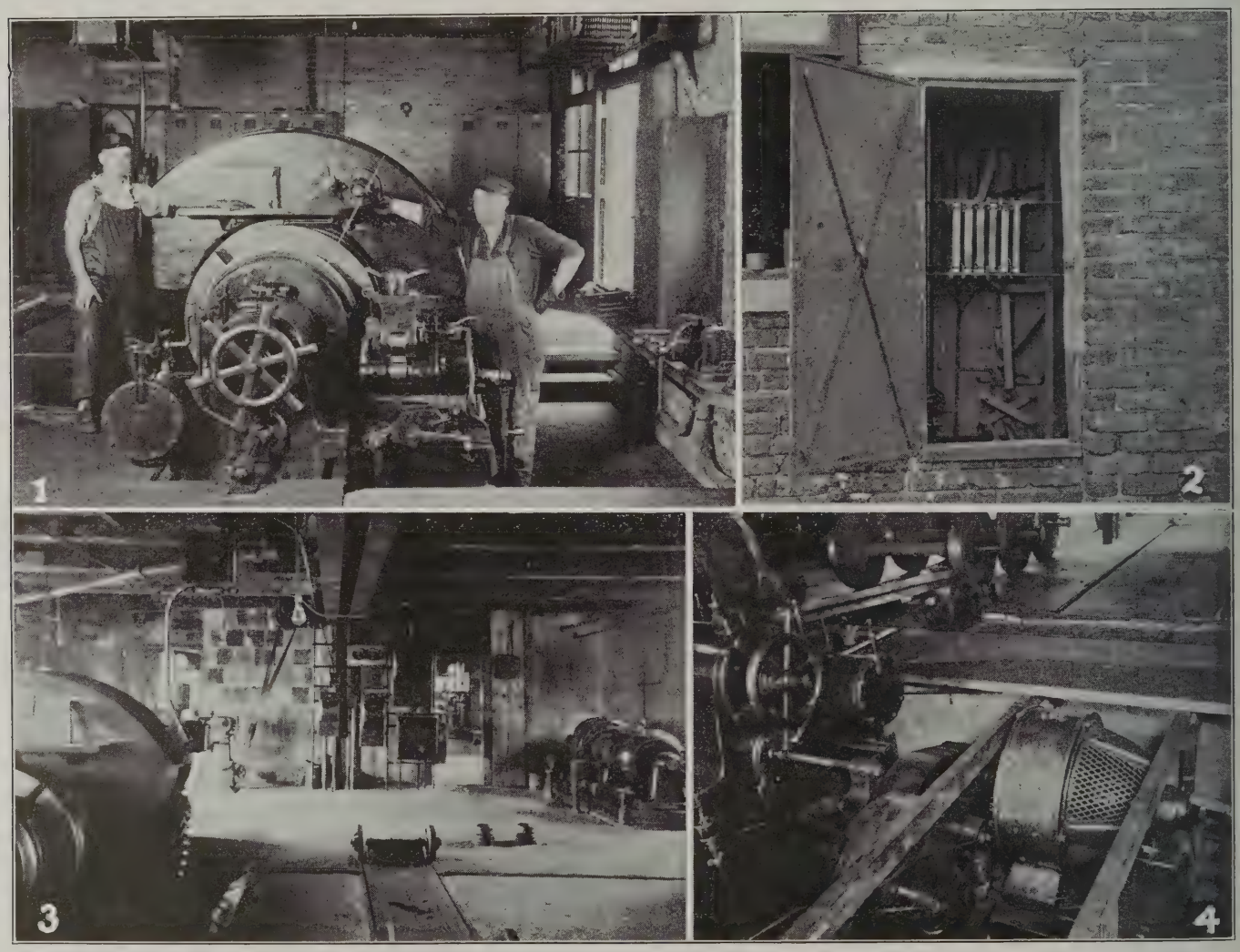


Fig. 1—The Lathe With a Pair of Wheels in Position for Turning. Fig. 2—A Back View of the Shunt-Field Control Cabinet. Fig. 3—A General View of the Room Showing a Part of the Lathe, the Starter, Switch Cabinets and Motor-Generator Set. Fig. 4—Some of the Floor Planks Removed to Show the Main Driving Motor

operated at a slow speed through a hard spot. A ballast resistor is permanently in the circuit and limits the initial rush of current to three or four times the full load current.

The speed control is handled by means of the shunt field and a field rheostat. The slowdown is accomplished by a shunted armature control which will provide a practically constant reduced speed under all conditions of load. Reversing is an emergency condition which is taken care of by means of a double throw knife switch.

To provide power for the wheel lathe and a few smaller shop tools, three new 50-kva. oil-cooled transformers were installed outside of the shop mounted on a platform between two poles. The wires from the transformers are carried in two-inch conduits to the switchboard. The enclosed safety switches used on all circuits are mounted together with the field series field. The suddenly increased field and reduced armature current of course reduce the speed quickly.

Further speed control can be had by moving the dial on the panel board or cabinet, shown back of the machinist in Fig. 1. This speed control is used for getting the desired cutting speed for wheels of various diameters and turning the dial cuts in or cut out some of the resistance in series with the shunt field.

It was not possible to mount the shunt field control cabinet out in the room far enough for a repair man to work behind it, so the cabinet was placed in a hole cut in the wall, thus allowing plenty of light and room for working on the connections and at the same time placing the cabinet in the most convenient position for the machinist. The back of this cabinet with the door open is shown in Fig. 2.

The motor generator set is shown at the right in Fig. 3, and at the center may be seen the starting

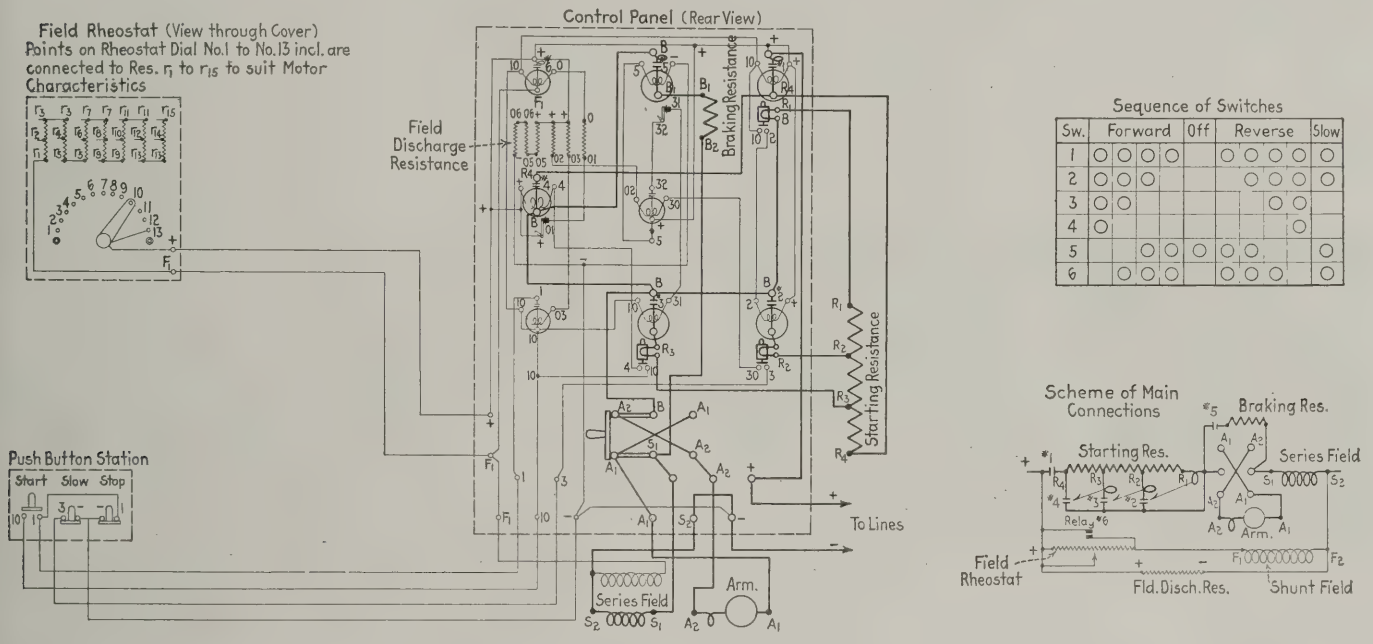


Fig. 5—Wiring Diagram Showing Control Circuits

rheostat and with the d. c. meters on a pipe framework.

The motor-generator set consists of 112-hp., 440-volt, three-phase motor and a 75-kw. d. c. generator. Several other d. c. motors used for the operation of small lathes and shop machinery are supplied with d. c. power from this same generator.

A general view of the lathe is shown in Fig. 1. The man at the right is a machinist and the one at the left his helper. A single control button on the helper's side of the machines provides an emergency stop, and the machinist has three control buttons located directly in front of him, which start, stop and reduce the speed respectively. The manner in which this speed reduction is effected can be readily seen from the small sketch of main connections, shown in the lower right hand corner of the wiring diagram, Fig. 5. Pushing the slow button closes the switch No. 5 and connects in the braking resistance across the motor armature terminals, thereby reducing the armature current and increasing the current through the compensator for the motor generator set and the enclosed safety switches for other circuits, all set up on pipe mountings.

The main driving gear of the lathe is a large herringbone gear which is located midway between the two wheels which are being turned. The hub or gear center is cut away to make a place for the car axle and a segment of the gear is hinged so that a pair of wheels mounted on their axles can be rolled in and out of the lathe from the side.

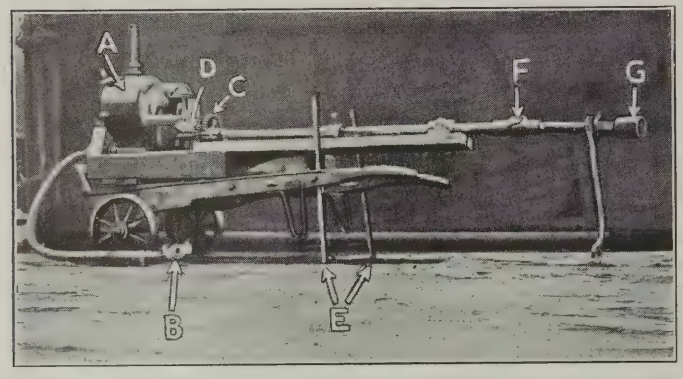
There is a plank floor all around the lathe and the motors are located under this floor. Some of the planks are removed in Fig. 4 showing the main driving motor. The five horsepower motor used for placing the wheels is located under the flooring on the opposite side of the lathe.

The electrical machinery used for this installation was furnished by the Westinghouse Electric & Mfg. Co., and the installation and wiring was handled by the railroad company's forces under the direction of L. B. Abbott, chief electrician, Chicago.

A New Method for Generator Testing

By B. C. Broyles, Electrician,
Southern Pacific Railroad, Los Angeles, Cal.

Numerous methods have been devised for the testing of car lighting generators, but most of them have been of such a nature as to require the removal of the generator from the car to some point where the test was made. In the coach yards of the Southern Pacific Railroad at Los Angeles another scheme has been developed for testing generators without removing them from their suspensions. The equipment used consists of a Chicago Pneumatic Tool



Letters Designate the Various Parts of the Equipment as Follows: A—Pneumatic Air Motor; B—Air Connection; C—5½-In. Gear; D—2½-In. Gear; E—Stakes to Hold Motor in Place; F—Universal Joint; G—Socket to Fit Armature Nut

Company's air motor with reduction gears, a universal joint and a universal socket. All of this apparatus is mounted on a hand truck so that it can be taken to any car in the yard and a connection made with the generator in about three minutes. After the air has been connected, the generator can be tested at varying speeds and any adjustment on the control board can be made under the same conditions as would exist if the car were in operation. In other words, the flexibility of the air motor is such as to give the equivalent of speeds varying from eight to 40 miles per hour.

Another big advantage claimed for this equipment is the fact that almost every railroad yard and depot is equipped with compressed air, whereas electrical circuits and apparatus are not always available.

Hot air never drove anything but a hot air motor, although many people place great reliance in it. One fraction of an ounce of help goes farther than all the hot air that is emitted through the human lips.

Thoughts

The fellow who isn't fired with enthusiasm is apt to be fired.

Excess is an arch enemy of success.

If top-notch effort yields you no happiness, there's something wrong either with you or your efforts. Sit down and do some analysing.

After all, you've got to give full, fair value. Or you won't last.

Carelessness and failure are twins.

The most valuable "system" is a good nervous system.

Saving is having.

If you have half an hour to spare, don't spend it with someone who hasn't.

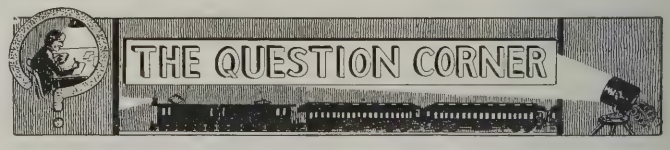
Don't simply see how you can "put in the day," see how much you can put into the day.

Never contrive to make it easy for your concern to get along without you.

Make sure the prize you chase is worth the price. If you cultivate your talents you'll always find an opportunity to use them.

When in a fix, sweating will get you farther than swearing. Let mules do the kicking.

Good times for all can only be the product of good work by all.—*Machinists' Monthly Journal.*



Answers to Last Month's Questions

1. *I recently had to make a few changes in a call bell system, which at first seemed to be quite difficult. The job was to install two extra bells and pushes. The additional equipment consisted of another bell at station* **A**, *to be operated from a push button at station* **B**, *and a second bell to be situated at station* **B** *to be operated from a push button at station* **A**. *This equipment was in addition to the two buzzers already in operation at the respective stations. Between station* **A** *and station* **B** *there was a stretch of 800 feet with several floors of hard wood and concrete and for a distance of 300 feet the wires ran underground. With 50 feet of wire on hand, and no means of obtaining any more, it was required that the job be done in a hurry. I did have, however, plenty of switches and push buttons of various kinds and also plenty of dry*

cells. I would like to see some of the solutions from other readers of the Railway Electrical Engineer. I believe there are plenty of ways to hook up this little system.—A. H. M.

2. I have run across a problem that puzzles me or else

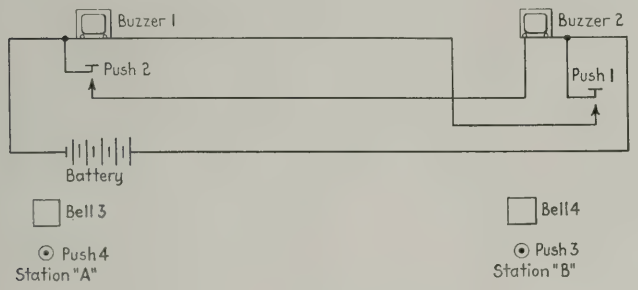


Fig. 1—Wiring Diagram Before Additional Apparatus Was Connected

there is something missing. I am sending you the problem to get some information and I would like to have you put it in the Question Corner and give an explanation how to work it.

The generator in the sketch delivers 6 kw. to the line

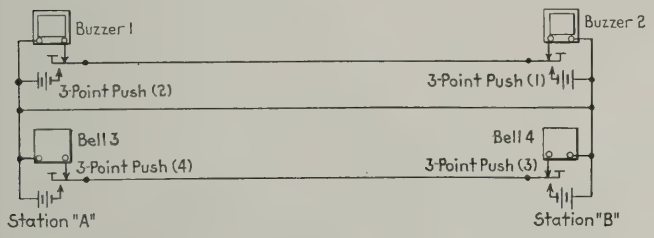


Fig. 2—Diagram Showing How Question No. 1 Was Solved

and the motor uses 5.7 kw. It is required to find the (a) watts lost in the line; (b) voltage and current of the motor; (c) brush potential of generator.—C. B. F.

* * *

The bell and buzzer wiring problem illustrated in Fig. 1 did not bring forth any solutions from our readers. We therefore publish A. H. M.'s own solution shown in Fig. 2. In describing his work he writes as follows: "To make a long story short, I did the job inside of one hour and had some wire left over. I saved something like 2,000 ft. of wire; also a lot of hard work."

* * *

Question No. 2, Fig. 3, brought a number of solutions, but all of those who attempted to answer this question labored under the same feeling as C. B. F.—that there was something lacking in the problem as presented. This,

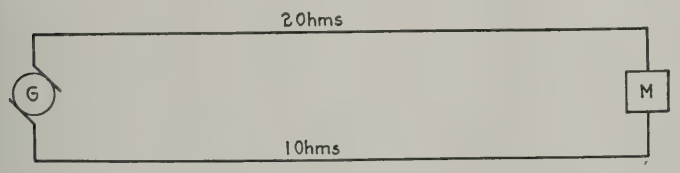


Fig. 3—Wiring Diagram of Question No. 2

however, is not the case, as there is sufficient information given, if it is used correctly. The following solution shows that it can be done:

If the generator delivers 6 kw. to the line and the motor uses 5.7 kw. it is clear enough that the watts lost in the line will be the difference between 6 kw. and 5.7 kw., or .3 kw.

The second step requires a little algebraic notation with Ohm's law formulæ for its solution, the object being to find the current passing through the motor.

$$E = IR \quad (1) \qquad I = \frac{W}{E} \quad (2)$$

where I is the current passing through the motor
E is the voltage drop in the line
R = resistance of line = 3 ohms

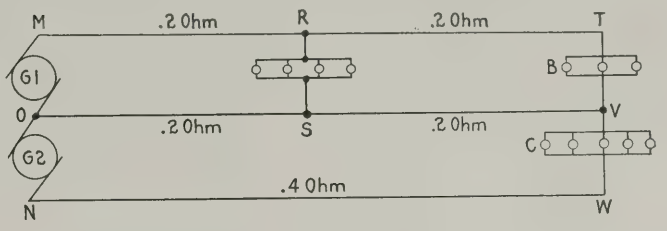


Fig. 4—A Three-Wire Problem for November

W = watts lost in line = .3 kw. or 300 watts.

If we substitute the known values in equation (1) we have

$$E = I \times 3$$

Then taking this value of E we substitute it for E in equation (2) and the result is

$$I = \frac{300}{I \times 3} \text{ or } I^2 = 100$$

$$I = 10 \text{ amperes.}$$

Having found the current through the motor and knowing that the motor uses 5700 watts, the voltage of the motor terminals is found by using the formula,

$$E^1 = \frac{W^1}{I}$$ where W^1 = watts used in motor and I is current passing through the motor, and E^1 is the voltage at motor terminals

$$\text{Then } E^1 = \frac{5700}{10} = 570 \text{ volts at motor terminals.}$$

The potential of the generator brushes is clearly the voltage of the motor plus the line drop, and the line drop may be found by using equation (1) again, E = IR
where E = the line drop in volts
I = the current in the line in amperes
R = the resistance of the line in ohms.

Substituting the known values of I and R the result is

$$E = 10 \times 3 = 30 \text{ volts.}$$

This value added to the voltage of the motor equals the potential of the generator brushes,

$$570 + 30 = 600 \text{ volts.}$$

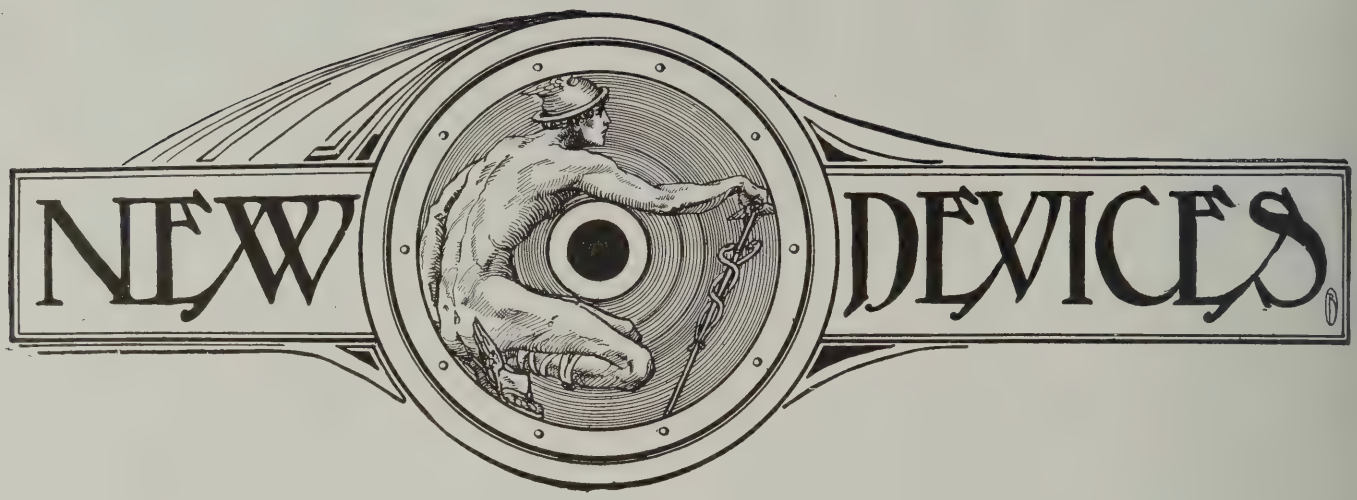
It will be noted that the current in the line is the same as that in the motor.

* * *

Questions for November

Assume that each lamp in Fig. 4 takes 2 amperes and that the resistance of the lamps remains constant. The brush potential of each generator is 112 volts. Find (a) the line drop in each section, (b) the voltage across each set of lamps, (c) the power delivered by G1 and G2. If a break should occur in the neutral between O and S, what would be the values of (a), (b), and (c)?

If a break should occur in the neutral between S and V, what would be the values of (a), (b), and (c)?—C. B. F.



Welding Sets for Medium and Heavy Duty

Two types of gasoline engine-driven arc welding sets, one for medium or intermittent duty, and the other for heavy duty, have been developed recently by the General Electric Company, Schenectady, N. Y. Both outfits are well adapted to industrial plants where the work to be done is located in odd places and is not sufficient to warrant the installation of permanent equipments. Their particular field, however, is in places where electric power is either unavailable, inconvenient or costly to bring to the work, as at outlying points on railroads.

The medium duty equipment shown in Fig. 1 was designed particularly for intermittent duty. The generating unit consists of a type WD 10-4 kw., 1200 r.p.m., 60/20 volt, 200 ampere generator, directly connected by a flexible coupling to a Matthews, Model F, four-cylinder, four-cycle, 20-hp. gasoline engine. The engine, radiator, generator and welding panel are assembled on a rigid cast iron base which in turn is mounted on wooden skids.

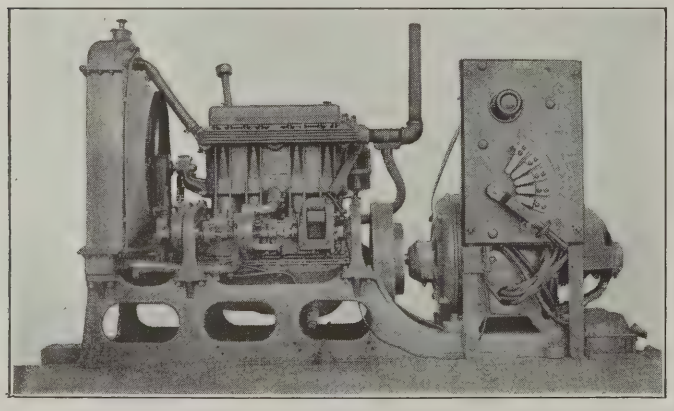


Fig. 1—General Electric Arc Welding Generator for Intermittent Duty Driven by 20-Hp., Four-Cylinder Gasoline Engine

The set is 86 in. long, 28 in. wide, and has a net weight of about 2,000 lb., making a light and compact affair to move about. The gasoline engine used with this outfit has been especially adapted to the requirements of intermittent welding service. It is of the overhead valve type, the cylinders being cast in block with the upper half of the crank case. The lubrication is a combination of splash and force feed, except where special conditions require the addition of a pump which is driven by the accessory shaft.

The generator is self-exciting and regulating, giving practically constant energy throughout the working range. It gives a no load, or striking voltage of 60 which automatically decreases to the proper welding voltage (usually 18 to 20 volts) when the arc is struck. It is driven at a speed of 1200 r.p.m., has a normal output of 4 kw. and delivers a maximum working current of 200 amperes. The panel carries the generator field rheostat and series field dial switch by which the current can be adjusted from 200 to 75 amperes in 25 ampere steps. A reactor choke coil mounted on the set and connected in the welding circuit protects the generator from current surges.

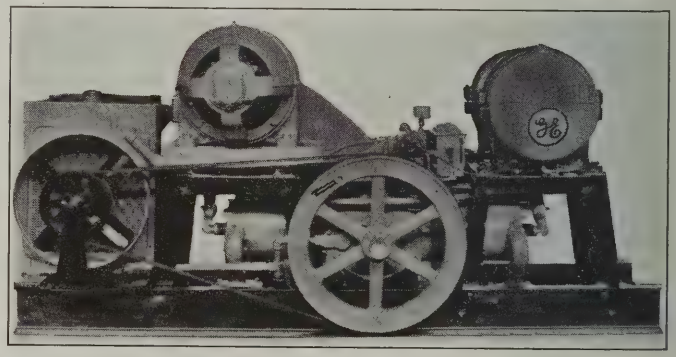


Fig. 2—Heavy Duty, Arc Welding Set, Driven by 20-Hp., Two-Cylinder Kerosene Engine

The heavy duty equipment (Fig. 2) can be arranged to supply either one or two welding circuits. It consists ordinarily of a 20-hp. two-cylinder opposed Reliable gasoline engine, a type WD 9 generator and welding panel, the whole mounted on a welded structural steel base with a net weight of 2,400 lb. for the single operator equipment and 3,200 lb. for the double operator equipment.

The gasoline engine is designed for continuous operation at rated output. Careful balancing practically eliminates vibration and the horizontal cylinder and relatively small flywheel makes possible a compact assembly with the rest of the outfit. It is said to run on kerosene, distillate, gasoline or natural or artificial gas, with a fuel consumption per brake horsepower hour not exceeding one pint of kerosene, distillate or gasoline, 10 to 12 cans of natural gas, or 17 to 22 ft. of average illuminating coal gas.

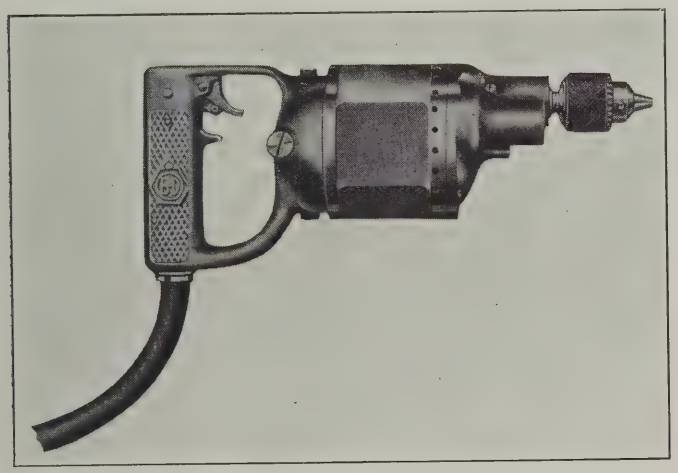
The generator is driven by a silent chain running in oil, and except for the speed, its characteristics are similar to the WD 10 generator which forms part of the medium

duty outfits. The speed is 1750 r.p.m. instead of 1200 r.p.m. and the motors differ somewhat in the windings because of the difference in speed and service requirements. An ammeter is mounted on the panel of each heavy duty equipment, but in other respects they are identical with those of the medium duty sets. A mere change of location constitutes the only difference between the reactors of the two sets.

Light Weight Portable Electric Drill

The portable electric drill, shown in the illustration, is designed for drilling holes up to ¼ in. diameter in either metal or wood. The drill weighs but 5 lb., being constructed of an aluminum alloy. It has a double reduction gear which gives a no-load speed of 1,600 r. p. m. The stub tooth gears which are used are cut from chrome nickel steel, heat treated and run in grease in a grease tight gear box. Ball bearings are removable and renewable. The motor mechanism is readily accessible, the brushes being capable of removal from the outside of the case, while the removal of four screws leaves the motor commutator, switch mechanism, field leads and cord terminals entirely exposed.

The location of the drill spindle, together with the fact that the apparatus is equipped with a pistol grip and



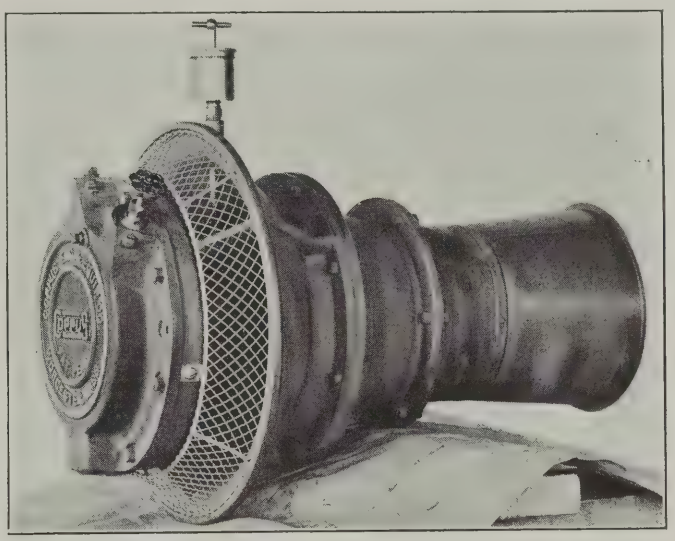
A 5-lb. ¼-in. Drill With Pistol Grip and Trigger Switch

trigger switch, make the drill particularly adaptable for close corner work, as it is possible to drill within about an inch of any obstruction. A special light weight, rubber covered cable is supplied and a clamp is provided in the pistol grip so that strains on the cable have no tendency to pull the terminals loose from the switch. The new unit is being marketed by the Black & Decker Manufacturing Company, Baltimore, Md.

Propeller-Type Blower of Novel Design

The screw blade, propeller-type blower, shown in the illustration, is made by the Coppus Engineering & Equipment Company, Worcester, Mass., the principal new feature of this design being a stationary guide vane beyond the propeller so arranged that the air current on leaving the propeller is radially subdivided by the individual guide vane blades and taken up by them without shock. These blades have a curvature increasing in the direction of rotation of the propeller and concentrate the air current, giving it a further acceleration inside of the stationary guide vanes so that a considerable part of the pressure is obtained in the latter. The end thrust is therefore mostly taken up by the stationary guide vane casing.

Moreover, the delivery of air in this blower is parallel to the axis. In other words, the air leaves in the same direction as it enters and in the case of long pipes subject to leakage two or more blowers can be installed between the ends, thus delivering a positive flow of air at low pressure and small resultant leakage. It is claimed for this propeller blower that its efficiency runs up to 80



The Coppus Blower Receives and Delivers Air Parallel to the Axis

per cent; that the power consumption at constant speed is practically unaffected by variations in air delivery or pressure and that the blower can operate against pressures up to eight inches of water. On account of these advantages, the blower is adapted to use in providing forced draft, induced draft, main and individual room or tunnel ventilation, air heating and drying installations, cooling of electric motors and generators, ventilation of factories, boiler rooms, etc.

New Non-Breakable Attachment Plug Cap

Attachment plug caps used on such devices as electric drills and similar small portable motors are frequently and annoyingly broken, and the device put out of service. To eliminate this source of trouble and expense the specialty and switch department of the Cutler-Hammer Mfg. Co., Milwaukee, has brought out a steel-clad cap which is exactly like the standard cap (fitting all plugs and receptacles of standard design), with a protecting jacket of steel. This cap, called the "Dreadnaught," was brought out through the request of an appliance manufacturer who realized that such minor troubles as broken caps often reflect adversely, not only upon the caps but on the appliance itself.

Steel Clad Cap

General News Section

The Lakewood Engineering Company of Cleveland has moved its Philadelphia office from the Widener Building to the Franklin Trust Building.

The reasearch department of the Radio Corporation of America under the direction of Dr. A. N. Goldsmith, has recently made important improvements in tape recording receiving systems for transatlantic radio signaling.

The wide extension of radio broadcasting service from a number of centers throughout the country, by means of which news items and musical concerts are given by radio telephony, has created a large demand for radio receiving equipment.

During the first nine months of 1920, electric locomotives, valued at $844,130, were exported from this country, according to Commerce Reports. In 1921, for the same period, the value of electric locomotives exported was $1,506,877.

Gilbert C. Lamb, formerly with The American Railways Company, Philadelphia, and the General Electric Company, Schenectady, has become associated with the engineering department of the Condit Electric & Manufacturing Company of So. Boston.

P. S. Jones, with the Cutler-Hammer Manufacturing Company, has been made branch manager of the Pittsburgh office. A. G. Pierce, of Pittsburgh, continues as manager of the central district, comprising the Cleveland, Pittsburgh and Cincinnati offices and territory.

G. R. Watson, formerly electrical supervisor for the Pullman Company at Chicago and later representative of the Crouse-Hines Company at Cincinnati, O., has been appointed general sales manager of the Wadsworth Electric Manufacturing Company, Inc., with headquarters at Covington, Ky.

The Habirshaw Electric Cable Company has increased the output of its Bridgeport plant by putting on a night force. The output has thereby been increased to 45,000,000 ft. of wire per month. The Bridgeport plant is now running at full capacity and the company anticipates being able to continue operation at this rate for some time to come. No phenomenal increase of business is looked for at the present time, but there is a heavy demand for small sizes of code and telephone wire.

F. L. Kellogg, manager of the New York branch at 25 West Forty-third street, New York City, of the Electric Storage Battery Company, Philadelphia, Pa., has been appointed district manager of the North Atlantic district, with headquarters at 25 West Forty-third street, New York. F. F. Sampson, manager of the Exide depots and garages, succeeds Mr. Kellogg as manager of the New York branch, with D. P. Orcutt as assistant manager. The entire sales organization in New York City was recently consolidated and Mr. Sampson was appointed manager and Mr. Orcutt assistant manager.

Plans are now nearing completion for the construction of three ferry boats by New York which, for the first time in the history of the city, will use the electric drive. The vessels will start a new ferry service between Cortlandt street and St. George, S. I.

The ships will be equipped with turbo-generators, with the direct drive, of about 3,500 horsepower. The boats will be 230 feet in length and 60 feet over all in width. They will have a capacity of fifty vehicles on the lower decks and 1,500 passengers. The boats are to be completed and ready for operation in May, when the new service will be started.

The city has an appropriation of $1,360,000 for the construction of the boats. At the time this fund was provided costs were considerably higher than at present, and it was intended to build only two boats. It is now believed that it will be possible to provide three, at a cost of approximately $450,000 each.

English Road's New "Articulated" Train

The Great Northern (England) has recently placed an "articulated" train in its London-Leeds service, according to the Railway Gazette (London). The train consists of five cars. At the head end of the first car there is a truck as well as at the rear end of the last car. Each remaining truck is so placed as to carry the weight of the ends of two cars and only one truck is provided at such places. Consequently the five cars are carried on six four-wheel trucks and the train is in reality nothing more than a long car in five movable segments which cannot be uncoupled. Additional cars can be added at the head or rear ends in the usual fashion.

The advantages claimed for this style of construction are: easy riding because of practically complete avoidance of oscillation; considerable reduction in weight; permanent connections between cars can be made weatherproof; absence of noise and clatter of ordinary couplings.

This is not the first articulated train on the Great Northern, it is said, but it is the newest and best equipped. The middle "car" of this train is a kitchen car, with a dining car at either end of it. The head and rear cars are coaches.

Proposed That Italy Take German Indemnity in Railway Electrification Material

Reports forwarded by Assistant Commercial Attaché Osborne, of Rome, and made public in Commerce Reports indicate that the director general of the Italian State Railways is suggesting that the government have the reparations account settled in part by requiring the Ger-

mans to hand over material which could be used in electrifying government railways. The office of the auditor general is said to oppose this means of settlement and to consider it preferable to have the adjustment of reparations made on a strictly money basis.

The reports state that plans have been completed for the electrification of the Bologna-Verona-Brenner, Pisa-Leghorn, and Venezia Giulia lines, as well as for a shortened route between Rome and Naples. Studies are being made for the possible electrification of the Naples-Reggio, Calabria, and Paola Cosenza lines.

Electrification of Japanese Railways

The journal of the Yokohama Chamber of Commerce states that the Japanese railways are to be electrified according to a plan now being worked out by the Department of Railways. First the entire Tokaido line and then a part of the Central line will be fitted up for electrification, the work extending in due course to all other lines. As soon as the department's plan is completed it will be presented through the cabinet to the Diet at its next session.

Traffic on the Tokaido line is increasing greatly each year and adequate accommodation is lacking for the transportation of passengers and freight. To expedite the service, automatic signals have been installed, but it is anticipated, however, that in a short time the traffic capacity of the railways will be found inadequate to meet the needs of the increasing business.

The first lines to be electrified will be the entire Tokaido line from Tokio to Kobe and a part of the Central line between Iidamachi station in Tokio and Kofu where many tunnels make transportation slow.

Overhead Wire Crossing Specifications

Overhead wire crossing specifications were commented on by H. M. Gould, Department of Street Railways, Detroit, Mich., in a discussion of the report of the committee on power distribution of the American Electric Railway Assocation. Mr. Gould said:

"From an examination of the various crossing specifications which have been issued by certain Public Service Commissions and those advocated by certain steam railroads, the writer is of the opinion that greater progress would be made if less attention were paid to details and the problem attacked upon broader lines. It would be better for everyone concerned if a broad, general crossing specification were in universal use instead of detailed specifications in use in some states and no specifications in other states."

Trolleys to Cooperate with Steam Roads in Carrying Freight

The day will undoubtedly arrive when electric lines will be used in a cooperative plan with the steam railroads and with motor lines for the movement of freight. The foregoing is the substance of a statement made by J. L. O'Toole, of the Public Service Railway, Newark, N. J., in speaking recently before the New Jersey Industrial Traffic League. At the same time Mr. O'Toole told of a law which was passed a number of years ago giving street railways the right to carry freight in municipalities where permission was given by the governing body. An amendment to this law made it unnecessary to secure permission to carry freight from municipalities of less than 12,000 population, and at a later date electric railways were given permission to carry freight from 11 p. m. to 6 a. m. without the permission of municipalities. The fact was emphasized by Mr. O'Toole that the investment of the amount of money required by this plan was not warranted at the present time.

Disastrous Fire at Weehawken, N. J.

The freight piers of the Erie Railroad, on the Hudson river, at Weehawken, N. J., about a half mile south of the West Shore Railroad passenger terminal, were damaged by fire on November 3 to the extent of about $2,000,000, the loss including 15 freight cars and great quantities of merchandise in the storehouses and in the

Photo by International

Fighting the Flames Twelve Hours After Fire Started

cars. Of the seven piers at this place, only three are left standing. The fire started on pier D and this with piers A, B and C was destroyed with its contents; also a four-story brick warehouse. The freight destroyed consisted largely of oil, salt, lumber and flour. Eleven lighters and barges lying close to the piers were damaged, some of them badly.

The World's Greatest Radio Station

The most powerful radio station that has yet been constructed was formally opened on November 5, when President Harding, at Washington, pressed the key which actuated the automatic sending device, thereby sending out a message which was received in 29 foreign countries.

The station is situated about 70 miles from New York, near Port Jefferson, Long Island. The magnitude of the station may be realized when one considers that the area spanned by the antennæ comprises 10 sq. miles. The arrangement of the station and aerial wires is such that they resemble a gigantic wheel, with the powerhouse at the center, from which 12 sets of antennæ radiate, not unlike the spokes of a wheel. So far, only two sets of towers have been constructed, but it is planned to erect the other 10 sets as it becomes necessary. The antennæ towers are 410 ft. high and carry cross arms 150 ft. long.

These cross arms support an aerial, consisting of 16 silicon bronze cables ⅜ in. in diameter, which are stretched horizontally from tower to tower, a distance of 1,250 ft. Approximately 50 miles of this cable has already been used for the first three sections. The ground arrangement for each antennæ consists of 450 miles of copper wire buried in the ground.

A unique feature concerning this radio station is the fact that it is operated by remote control from the New York office of the corporation over specially constructed wire lines. The receiving station is located at Riverhead, Long Island, approximately 16 miles away from the sending station. There are no operators located at either station, the signals being automatically transferred to the New York office.

By means of automatic equipment for sending, a speed of 100 words a minute is possible, and when the entire installation is completed it will be possible to send 12 different messages at this rate simultaneously. The power that will be eventually required to operate the station will be approximately 20,000 kw.

Fuel Saving About One-third

The problem of railroad electrification is essentially one of finance, and the saving in coal which can be effected is something less than one-third according to a statement made by William J. Cunningham, professor of transportation, Harvard University, in an article commenting on the Superpower Survey report which appeared in the New York Evening Post. In this connection Mr. Cunningham said: "It is interesting to compare this theoretical saving of two-thirds of the fuel with the actual figures for the Norfolk & Western. In discussing the subject before a joint meeting of the Societies of Electrical and Mechanical Engineers in New York in October, 1920, the chief electrical engineer of that road stated that a comparison of fuel consumption on the electrified divisions with tests made with modernized Mallet type locomotives under similar conditions indicated that the saving in fuel by electrical operation was 29.3 per cent. This is less than one-third. If the Superpower Survey engineers had assumed a saving of one-third instead of two-thirds (the former is closer to the facts) the estimated fuel savings would be cut in two. A tendency to favor electrification is shown also in other items, such as in the allowance for steam locomotives released.

"As has already been stated, the problem is essentially one of finance. In the case of a railroad that has an investment in road and equipment of say, $100,000 per mile, something more than a questionable return of 14 per cent is needed to induce recommendations for an investment of, say, $40,000 more per mile for electrification. On every hand there are needs for other investments.

Personals

D. McFarlan Moore has recently become a vice-president of the Illuminating Engineering Society. Mr. Moore has been well-known in electrical circles for a number of years, especially in connection with his vacuum-tube lighting system. He is at present manager of the Moore Light Department of the General Electric Company at Harrison, N. J. He is a Fellow of the Institute and has served in other technical bodies.

Obituary

Harry C. Meloy, supervisor of electrical appliances, New York Central lines west of Buffalo, died suddenly on Thursday, October 13, while on a business trip in Chicago. Mr. Meloy was born on February 16, 1865, in Bedford, Pa. After completing a high school education in Bedford, Mr. Meloy entered the railway shops of the Pennsylvania at Altoona, Pa., and served an apprenticeship course there. After completing the apprenticeship course he was employed for a short time at the Swissvale plant of the Union Switch & Signal Company, after which he accepted a position as chief electrician of the Norfolk & Western at Roanoke, Va., which position he held for ten years. In April, 1902, he left the service of the Norfolk & Western to accept a position on the Lake Shore & Michigan Southern as chief electrician in charge of car lighting. In 1910 he was promoted to supervisor of electrical appliances, and in 1914 the Lake Shore was consolidated with the New York Central. After the consolidation Mr. Meloy continued to hold the title of supervisor of electrical appliances on lines west of Buffalo, which position he held until the time of his death. Mr. Meloy was a charter member of the Association of Railway Electrical Engineers. He was president of the association in 1908, and from the time of its organization Mr. Meloy had always been interested in furthering the interests of the association.

Harry C. Meloy

Trade Publications

The Trumbull Electric Mfg. Co., Plainville, Conn., has reduced its prices on meter service switches to contractors 18 per cent, according to a leaflet sent out with the August issue of Trumbull Cheer.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has recently published catalogue No. 12-A, showing its various types of safety switches and panel boards. The catalogue contains 64 pages and is well illustrated.

Ivanhoe-Regent Works of General Electric Co., Cleveland, Ohio, has issued a booklet of 12 pages, entitled "Make It Pay," presenting arguments for better lighting and the merits of this company's products in home, plant and window display lighting.

The Martindale Electric Co., 11,737 Detroit avenue, Cleveland, Ohio, has issued a folder wherein it states that it has improved on its commutator stones by adding a handle, resembling a saw handle, which is claimed to give full protection to the hands and make the use of the stones both safer and more convenient.

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Railway Electrical Engineer

Volume 12 DECEMBER, 1921 No. 12

Indexes for the year 1921 have not been included in the regular monthly issue of the *Railway Electrical Engineer*. It has been found that many readers prefer to keep their copies unbound and for this reason a limited number of indexes will be printed. Any subscriber who desires a copy of the index should send a request to our circulation department so that it will be received not later than January 1, 1922.

Yearly Indexes

It is often necessary for engineers to decide whether electric power shall be transmitted over high voltage transmission lines or whether the energy shall be transported in the form of coal over the railroads. In other words is it best to build the powerhouse at the mine and send power over a transmission line to the center of distribution, or is it the best proposition to transport the coal over the railroads to the power plant located at center of distribution?

Transmission vs. Transportation

In general, this is a problem which applies only to large stations, but to a lesser degree it applies to many of the power plants used by the railroads. Where the distances are very small, or very great, local conditions or physical limitations will make the solution easy. Where the distance approximates 100 miles careful calculations are necessary if anything like correct relative advantages are to be arrived at.

There are, of course, under any circumstances, a number of factors involved aside from a comparison of relative costs. If the plant is located at the mine, it will be possible to secure a uniform grade of coal at a reasonable cost and the location will also insure freedom from a possible railroad strike. Transmission line trouble may be an important factor unless duplicate lines are built. If the distribution center is in or near a large city, it is probable that the real estate for the plant can be secured at a lower cost near the mine. In the case of large plants, the question of whether adequate water for condensing purposes is available or not is an even more vital consideration than coal.

The main question, however, is whether the cost of transmitting electrical energy is less or greater than the cost of the rail shipment of coal. A typical case was recently worked out by Harold W. Smith, general engineer, Westinghouse Electric & Manufacturing Company, and published in the *Electric Journal*. A distance of 90 miles was chosen and the rail transportation costs compared with the transmission costs over duplicate transmission lines 90 miles long with copper conductors of 500,000 circular mils. The result of the calculation showed that with power demands varying from 80,000 to 300,000 kw., the cost of transmission will vary from 0.22 to 0.12 cents per kilowatt-hour. With a modern plant burning 1.5 lb. of coal per kilowatt-hour and a freight rate of $2 per ton, the cost of transporting energy in the form of coal over the railroads would be equivalent to 0.15 cents per kilowatt-hour.

From this it appears that we may draw the rather surprising conclusion that the relative costs of transmitting electrical energy as compared with transporting a sufficient amount of coal to generate the same amount of energy may, in many cases, be very nearly equal. A poor load factor, of course, would operate against the transmission of electrical energy, while difficulties in making shipments, due to lack of facilities, would have the opposite effect.

Charging receptacles for car lighting batteries are invariably mounted under the car in a horizontal position and the opening is normally covered with a cap. It would seem that such an arrangement ought to prove quite satisfactory and no doubt in the majority of installations it does. If such were not the case it is more than likely that we should hear more about it. It is nevertheless a fact that sometimes the cap does not entirely protect the interior of the receptacle and eventually there is an accumulation of dirt which may become the source of much trouble. Recently our attention was called to the fact that a considerable number of these receptacles became grounded from the accumulation of dirt which must be entirely removed before the batteries can be charged from an outside source. This is especially true when the charging is done with 250 volts for it is readily apparent that under such conditions dirty receptacles could not be tolerated.

Charging Receptacles

It has been suggested as a possible remedy for troubles occasioned by dirty receptacles to change the mounting of the receptacle from the horizontal position, which is practically universal, to a vertical mounting. Such a change would probably require some alteration in the design of the bracket supporting the receptacle, but the receptacle itself would require no modification of any kind.

There is apparently no reason other than custom why charging receptacles are mounted in a horizontal position and if such difficulties as have been pointed out are prev-

alent to any considerable extent, it would seem advisable to give some further consideration to the matter of changing the mounting.

Welding Manganese Steel

That the successful accomplishment of electric arc welding results largely from a careful metallurgical study of the characteristics of both the parent metal and the welding electrode is clearly pointed out in the article describing the process of welding manganese steel, which appears on page 457 of this issue.

In view of the peculiar character of this metal, it is not surprising that those who have neglected to make a careful study of the phenomena which occur on heating and cooling, fail to make satisfactory welds. This lack of diligent study and care is without doubt one of the principal reasons why arc welding so frequently receives a set-back through the failure of some important weld. It is unfortunate that more thought is not given to the metallurgical side of welding, for without a knowledge of the behavior of metals under various heating and cooling operations, it is practically impossible to take advantage of the characteristics of the metal which are present. With manganese steel, for example, what a wonderful difference is found between the weld which is suddenly cooled with water and the weld which is allowed to cool gradually. Cooling a weld by quenching it with water immediately after each electrode is used, is not treatment for which the reason is obvious, and unless time has been taken to familiarize the operator with the water toughening process, the success of the weld in manganese steel is apt to be unsatisfactory. In a word, successful welding is accomplished not only by the use of proper material and equipment, but with the important addition of the thorough knowledge of the metallurgical characteristics of the material at hand.

Power for Outlying Points

Pumping plants, small stations and other railroad facilities located at outlying points are often so situated that it is not convenient to supply them with electrical power. Although the power consumption of such facilities is small, the need for power is none the less important. In many cases this can be obtained by co-operation with the signal department. An example of such co-operation is shown by one road which has designed its signal transmission line to provide sufficient additional power for the illumination of stations in the smaller towns, the lighting of a number of switch lamps and a reserve for emergency lighting in the case of accident or washout. At another point on this same road a coal dock is operated by a 15-hp. motor connected to the signal power line. In case such a transmission line is planned, it must be so designed as to provide a requisite amount of capacity. This is of particular importance, for if the starting of a motor should cause a considerable drop in the line voltage, the automatic block signals in that section might be released momentarily to the "stop" indication. The signal indications are, of course, of first importance and all other power requirements should be subordinated to them. Modern control apparatus, however, has now been perfected to such a point that a line failure, due to trouble at one of the points to which power is distributed, is a remote possibility. Certainly, the economies resulting from the use of automatic electrically-controlled machinery at isolated points, are so large as to warrant thorough investigation, and when such a line is to be built the requirements of both the signal and electrical departments should be considered.

New Books

Material Handling Cyclopedia. Edited by Roy V. Wright and John G. Little. Bound in cloth and leather; 850 pages, 1,500 illustrations, 11½ in. by 8½ in. Published by the Simmons-Boardman Publishing Company, Woolworth Building, New York City.

This is the latest addition to the library of transportation literature published by the Simmons-Boardman Publishing Company. The volume is a companion book to the Car Builders' Dictionary and Cyclopedia, the Locomotive Dictionary and Cyclopedia, the Shipbuilding Cyclopedia and the Maintenance of Way Cyclopedia.

The purpose of this cyclopedia has been to bring together in a single volume complete, practical working information about the many types of material handling devices used in industry. The purpose has been to make the contents of interest and value alike to the executive interested in reducing handling costs and to the operating man who is seeking information as to the types of material handling machines best suited for his needs, how they operate and where they may be obtained.

The definition section in addition to its purpose as a dictionary of material handling items, methods and devices, serves as an index to other sections of the book. Following the definition of each device receiving further treatment in the book is a reference to the page in the text section or catalog section on which the additional information appears. Thus, from the definition the reader is referred not only to the detail description, method of operation, and illustration of the device given in the text section, but as well to the page in the catalog section where the device which he has selected as best suited for his needs is described authoritatively by the manufacturers.

The illustrated text section, which directly follows the definition section, has been sub-divided into divisions corresponding to the general classification of machines. Thus the text contains separate sections devoted to hoisting machinery, conveyors, elevators, industrial and motor trucks, tractors and trailers, industrial rail transportation track, cars and locomotives, and handling systems. Each section is fully illustrated, the illustrations showing typical applications of the various machines as well as their general characteristics and appearances.

A catalog section of 150 pages supplements the information shown elsewhere in the book. In it the manufacturers of machines present detail descriptions and illustrations of particular devices referred to in the other sections of the book.

A general subject index covering the entire contents of the book is an additional help in making the information readily available.

Selecting Designs for Electric Locomotives*

Merits of Various Wheel Arrangements of Steam and Electric Locomotives Determined by Tests

By A. W. Gibbs
Chief Mechanical Engineer, Pennsylvania

THERE are certain questions as to electric locomotives such as the transmission of power from the motor to the driving wheels and the behavior of the complete locomotive considered as a vehicle, particularly with reference to its effects on track structure, which have not received adequate attention. These problems may best be studied with reference to approved types of steam locomotives and this paper deals especially with the results of a comparative trial of steam and electric locomotives which was made in 1907 to secure information in connection with the design of electric locomotives for the Pennsylvania terminal in New York City. It should be understood that at that time but a limited number of types of electric locomotives were available for comparison.

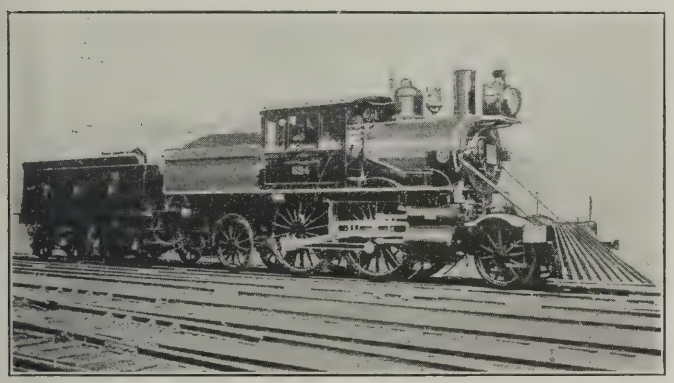


Fig. 1—Columbian Type (2-4-2) Locomotive

The greatest difficulties of the electric locomotive, other than financial, are mechanical rather than electrical. None of the mechanical arrangements to be described are ideal by any means, and we must not mistake the absence of heavy repairs in the early years of an installation as truly representative of the expenses which will be met later on.

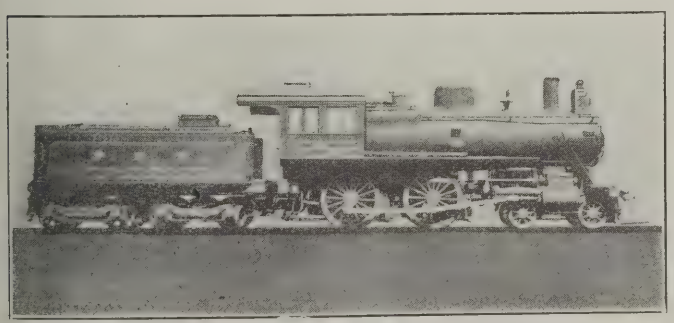


Fig. 2—American Type (4-4-0) Locomotive

At first blush it would seem that nothing could be more ideal than the connection of a revolving armature and a revolving driving axle. As a matter of fact, it is not at all simple for the reason that the driven axle not only revolves but is displaced bodily as well as angularly in the vertical plane. Moreover, these displacements of axles and wheels, which are not spring supported, occur suddenly, due to irregularities in the track, hence it is desirable to reduce the unsprung weight to a minimum.

The difficulties from these various disturbances are encountered principally at the higher speeds and are those with which we shall mainly deal. The different methods of communicating motion from the motor to the driving axle may be considered under the following designations:

A. That in which the armature is carried directly on the driving axle, the axle boxes sliding in vertical pedestals and the face of the field coils being parallel vertically on each side of the armature. In this construction the whole of the field coils can be rigidly secured to the frame and above the supporting springs. This arrangement permits the easy removal of the driving axles and wheels with the least disturbance of other parts. The disadvantages are the increase in the unsprung weight on the axle and the low center of gravity of the entire motor. So far this drive has been confined to direct current operation.

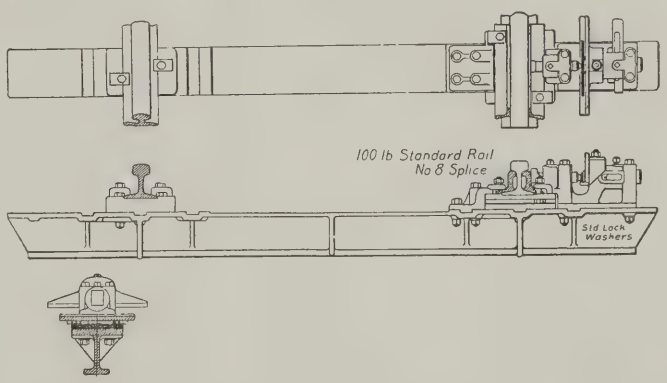


Fig. 3—Assembled Recording Tie

B. The geared drive, with the gear on the driving axle engaging a pinion on the motor, one end of the motor frame being carried in bearings on the axle, the other by proper nosing on the truck frame. The disadvantages of this arrangement are the low center of gravity of the motor as a whole, the considerable unsprung weight and the gear wear, principally that of the pinion. Usually the motors are in pairs between pairs of axles, and in consequence the gyratory disturbance is less than where the motor center coincides with that of the axle. This general type of drive, which is in common use in street car operation is, undoubtedly, the one having the widest application and operates with both alternating and direct current.

C. The quill arrangement in which the whole motor is

*Abstract of a paper read before the Franklin Institute, Philadelphia, Pa.

concentric with the axle in its normal position, but is not directly connected, the axial opening of the armature being larger than the diameter of the axle. The physical connection between quill and axle is by springs interposed between pockets in the periphery of the driving wheel center and the arms of a revolving spider connected to the armature. These springs not only transmit the driving torque, but also compensate for the axial disturbance of the driving axle. In some installations the motor frame as a whole is spring-supported, so as to assist in assuming a position concentric with the axle. The objections are the low center of gravity of the motor, the distance between the motors measured from the center of the truck, the fact that the motor can be removed from

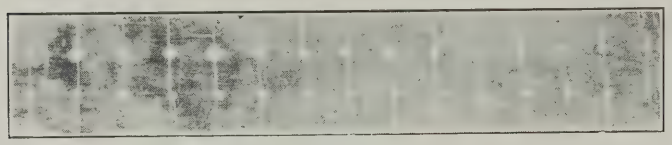


Fig. 4—Metal Strip Used in Recording Tie, Showing Impressions

the axle only by drawing one of the wheels, and that any lack of concentricity between the quill and the driving axle puts a continued and varying inertia stress on the torque springs.

Both arrangements "A" and "C" have the further disadvantage that the ratio of the speed of the motor to that of axle is unity, thus involving higher motor weights than when this ratio is greater.

D. A modification of the quill arrangement in which the quill is driven by one or more motors through spur and pinion arrangement. The advantage of this is that the motor parts are much more accessible than in the concentric type, and that the speed ratio of motor armature to driving axle may vary through a fairly wide range, and that where two motors drive the same quill the tooth load is that of a single motor. The disadvantage is the increased axle distance due to the width over two motors.

E. That in which one revolving element is a jack shaft

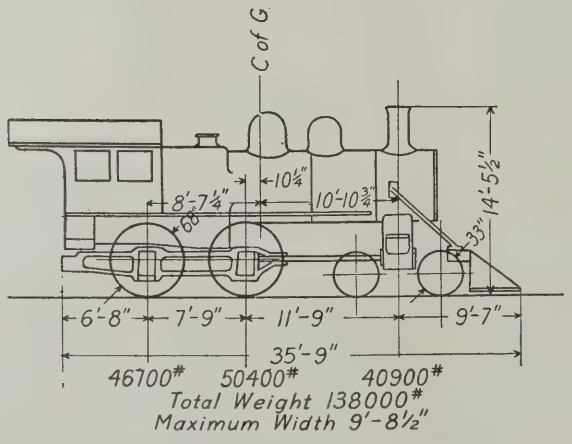


Fig. 5—American Type (4-4-0) Locomotive

driven by one or more motors and coupled by crank pins and rods to the crank pins of driving axles. The jack-shaft when placed in the horizontal plane of the driving axles maintains a fixed position relative to the driving motor or motors. The relation between them may be a second set of rods coupling the jack-shaft cranks to a similar pair on the motor; or the jack-shaft may be driven through spur or herring-bone gears cut on the periphery of the disk engaging pinions of one or more motors. These rod connections have been used more largely in Europe than here. The jack-shaft and rod combination is an exceedingly rigid one and the wheel arrangement forms a more rigid connection than in the case of steam driving through pistons. The advantages are that the removal of driving wheels does not involve electric com-

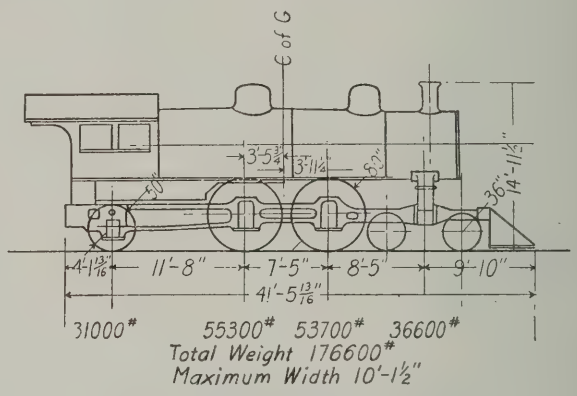


Fig. 6—Atlantic Type (4-4-2) Locomotive

plications, and that all driving wheels in the group act together, so that the full adhesion of the group is secured, and it is probable that a higher total adhesion will be available from groups than from single units where the slipping of one unit reduces the total adhesion. The disadvantages are mechanical complications involving exact quartering of all wheels and jack-shafts, the necessity of equal diameter of all driving wheels, and the heating of pins and maintenance of rod bushings. Contrary

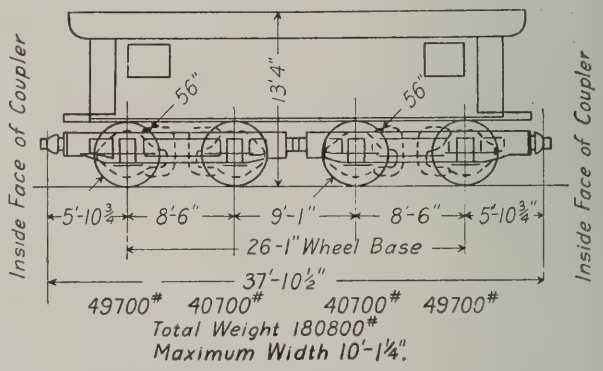


Fig. 7—Electric Locomotive No. 10,001, Geared Drive, Type B

to expectation the maintenance of jack-shafts involves no great difficulty.

In no type of electric locomotive drives are there counterbalance disturbances due to counterweights, as only rotating masses are in motion.

Starting Power of Locomotives

As governed by adhesion the motor-driven axle in starting has a relatively high adhesion because of the uniform torque of the motor. It is a well-recognized fact that static weighings of locomotives show considerable discrepancies on individual axles. How this discrepancy varies in moving locomotives is not known.

Assuming that the motor torque is greater than adhesion resistance, we have, where axles are individually driven, the adhesion of the axle with the lightest loading

governing the adhesion of the group. Where, on the other hand, there is a rod connection between the various axles, we utilize the full adhesion of the group. The presence of the coupling rods does not preclude the application of power to any axle or number of axles, though the usual practice has been to apply all the power to one or more jack-shafts and from them to a group of axles. This utilization of the full adhesion in starting is a matter of importance in any type of locomotive, as usually they will pull heavier trains than they will start.

In the earlier days of steam locomotives the aim was to

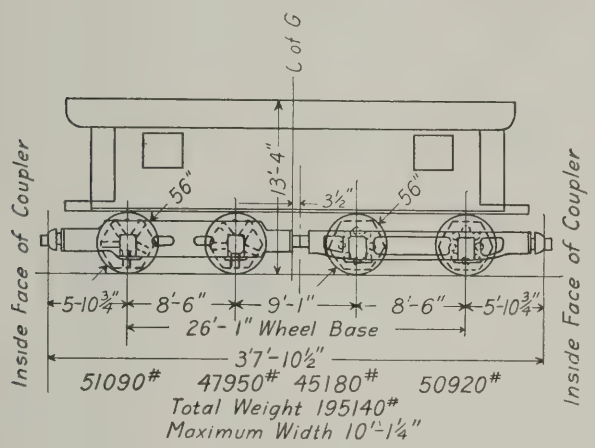


Fig. 8—Electric Locomotive No. 10,002, Quill Drive, Type C

keep the vertical center of gravity low with the idea that this was conducive to stability. Not until the Reading Railroad in its introduction of the wide firebox type of locomotive was forced to elevate the boiler so that the firebox would clear the driving wheels, was it recognized that this change had materially improved the steadiness of the locomotive as a vehicle. The reason, of course,

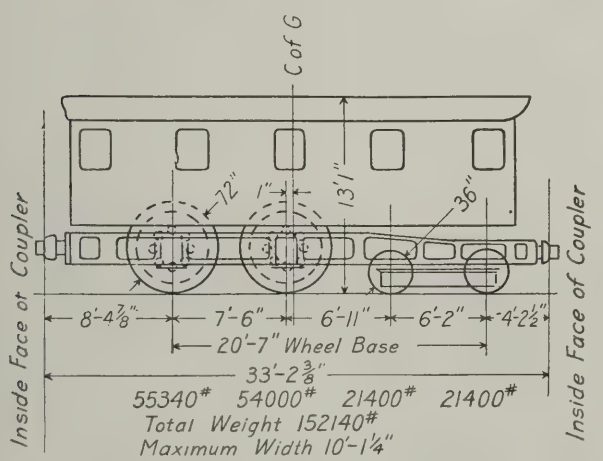


Fig. 9—Electric Locomotive No. 10,003, Quill Drive, Type C

was that the center of gravity of the parts above the springs acting as an inverted pendulum failed to respond to the many small disturbances which would otherwise have produced side shocks. Since that time designers have not hesitated to raise the center of gravity of the parts above the springs, and the present limits are chiefly those of overhead clearance.

One other steam locomotive lesson that seems to have been forgotten was that with a short symmetrical wheel arrangement with heavy overhanging weights distributed longitudinally of the whole machine, excessive lateral oscillations were set up which endangered the track and locomotive. Figs. 1 and 2 show locomotives of the Columbian or 2-4-2 type and the American or 4-4-0 type. Here are two types of almost the same total wheel-base with nearly the same height of boiler above rail. The weight of the 4-4-0 type was but 7 per cent greater than that of the 2-4-2 type. The 2-4-2 type was so unstable that it was soon condemned. The 4-4-0 type is notably a steady-running one and its performance will be graphically shown later. The reason for the difference in performance is probably that the wheel arrangement of the 2-4-2 was symmetrical, while that of the other was not.

When it became necessary to design locomotives to operate the New York terminal of the Pennsylvania Railroad two electric locomotives were designed and built.

Both consisted of two four-wheel trucks with motors for each axle. In both cases the trucks were articulated at the center and carried the necessary draft gear at the ends, thus the pull was transmitted through the frames of the trucks and not through the superstructure.

In one of these locomotives the motor drive was by

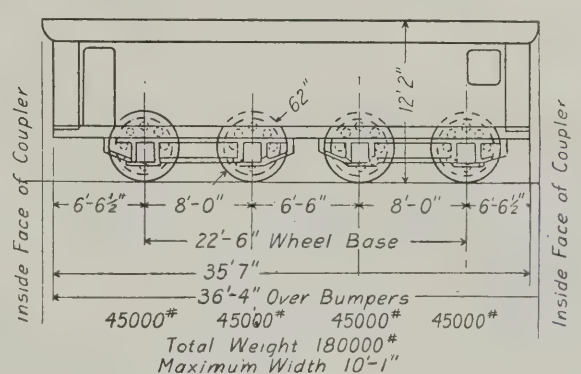


Fig. 10—Electric Locomotive No. 028, Quill Drive, Type C, with Pivoted Truck

gear, the second method referred to. The other was driven by four concentric motors through quills.

The wheel-base of both were identical, that of the trucks 8 feet 6 inches and the total 26 feet 1 inch.

Both operated by direct-current at 650 volts through third rail.

About the time that they were completed reports of troubles elsewhere made it very desirable that we should ascertain their performance before constructing the large number of locomotives necessary for the operation of the tunnels.

Method of Determining Lateral Impact

The line of the West Jersey was available for track and current, and it was decided to construct an experimental track with ties which would make some permanent record of the lateral impacts of the locomotives. As it was expected that the bad oscillations would occur on curves, if anywhere, only one end of each of the ties was arranged to register.

Fig. 3 shows one of these ties, the end at the outer rail being so constructed that the rail was free laterally, resting on rollers, resisted against outward movement by a bracket carrying a strip of boiler plate, movable longitudinally at will. Against this strip rested a one-inch steel ball which in turn bedded in a plunger bearing

against the outside face of rail. (Fig. 4 shows one of the impression plates carrying the record of 30 runs.)

The record obtained with this device was a species of glorified Brinell test, the depth of the impressions of the one-inch ball in the boiler plate being taken as a measure of the impact. After each run the plates were slipped longitudinally and adjusted to touch the ball, each single plate taking the record of 30 or more runs. It is to be clearly understood that this method carries with it some decided limitations which must not be overlooked. Each run, whether with one or more vehicles, made a single impression on each plate. While it was assumed that the indentation was that of the heaviest impact, it is possible that two or more impacts occurred on a single point with some cumulative effect. In some of the runs it is believed that this was the case. There was also some question as to the interpretation of the impressions. They were calibrated by static loading in the testing machine and also dynamically by falling weight.

The recording ties, 80 in number, extending over five rail lengths, or a total distance of 165 feet, were laid on a one-degree curve in the southbound track, near Frank-

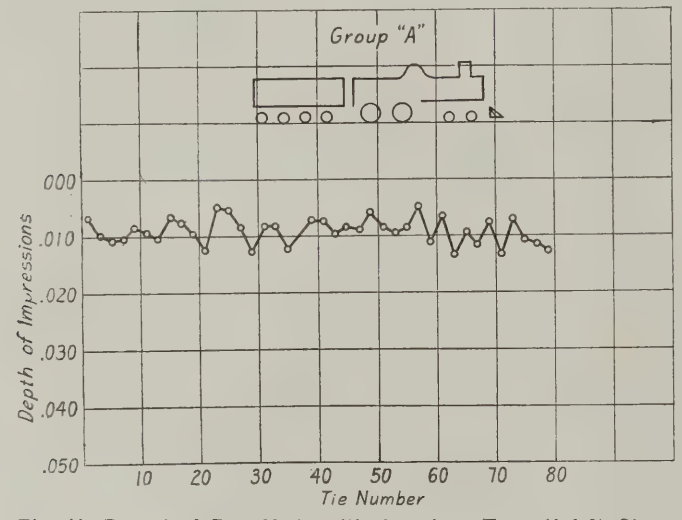


Fig. 11—Record of Run Made with American Type (4-4-0) Steam Locomotive at a Speed of 83.5 Miles Per Hour on Curve

linville, N. J., in 1907. There were 16 of the recording ties to each rail-length and at every splice on both rails the two ties at the splice were so located that the joint between the rails came between the ties, which at this point were 20 inches apart. The other 14 ties were spaced as uniformly as possible, taking into consideration the necessities for spacing at the rail joints. Tie No. 1 was placed about 28 ft. south of the point of curve. The super-elevation of the outer rail of curve was 3 in. and the elevation of the rail began at a point about 250 ft. north of the point of curvature.

Tie plates were used on wooden ties immediately south of the test track for one-quarter of the distance around the curve. The ballast used at the curve was gravel and cinder. The rails were P. R. R. section 100 lb. to the yard, in good condition. It was specified in arranging the experimental track that it should be lined up in about the best average condition of track used on this piece of road.

The tangent track approaching the curve from the north consisted of 100-lb. rails supported by wooden ties, single spiked. The substructure was of broken stone ballast with the exception of about 1,500 ft. north of the test track, in the vicinity of Clayton, where most of the runs were started and where cinder and gravel ballast were used.

After the completion of the runs on the curve, the recording ties were removed to the tangent north of Franklinville station, where the trials were completed. At this location the track consisted of 100-lb. rail with

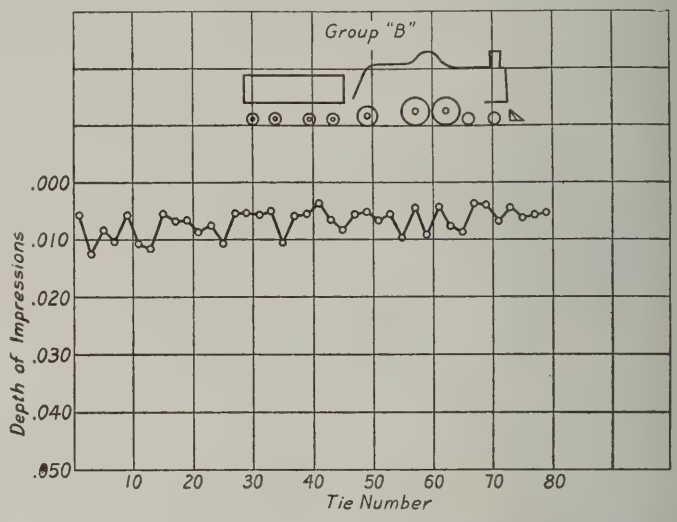


Fig. 12—Steam Locomotive, Atlantic Type (4-4-2), Speed 95.7 Miles Per Hour on Curve

broken stone ballast. The speed record was obtained by means of a series of trips, operated by the locomotive passing over them, which broke and made the circuit going to the chronograph. These trips were located such distance apart that at a speed of 100 miles per hour the time between trips would be one second. Four trips were used for the tests on the curve and seven for those on the tan-

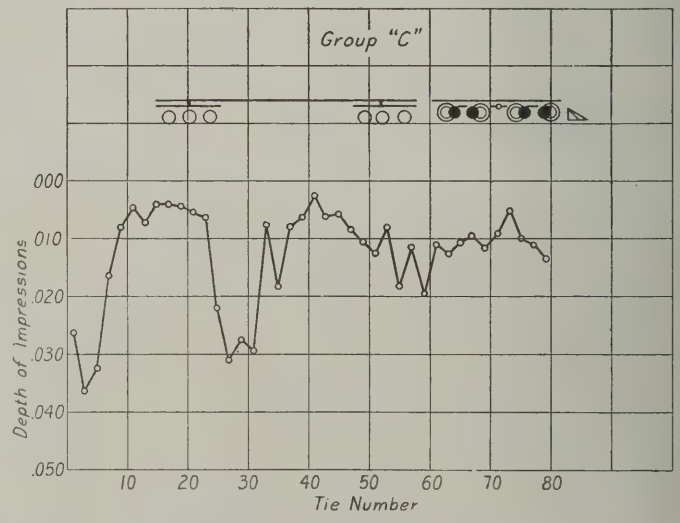


Fig. 13—Electric Geared Locomotive No. 10,001, Speed 71.5 Miles Per Hour on Curve

gent, the idea being that failure of one or two trips would not vitiate the record of the run.

Other apparatus used in the tests consisted of speed recorders on the locomotive, which were used only to obtain approximate speeds; and in some of the runs, there was placed on the locomotive a seismograph having three pendulums, giving vibrations in vertical, transverse and longitudinal directions.

The equipment available for testing included a wide variety of steam locomotives, and four electric locomotives.

The steam passenger locomotives selected were, one of the 4-4-0 or American type (Fig. 5), the other of the 4-4-2 or Atlantic type (Fig. 6).

The electric locomotives were Nos. 10,001 (Fig. 7) and 10,002 (Fig. 8) already described; No. 10,003, or American type, that is, with two pair of driving wheels and a four-wheel truck (Fig. 9); and No. 028, a brand-new locomotive belonging to the New York, New Haven & Hartford, which consisted of two four-wheel trucks pivotally connected to the body which carried the draft attachments (Fig. 10).

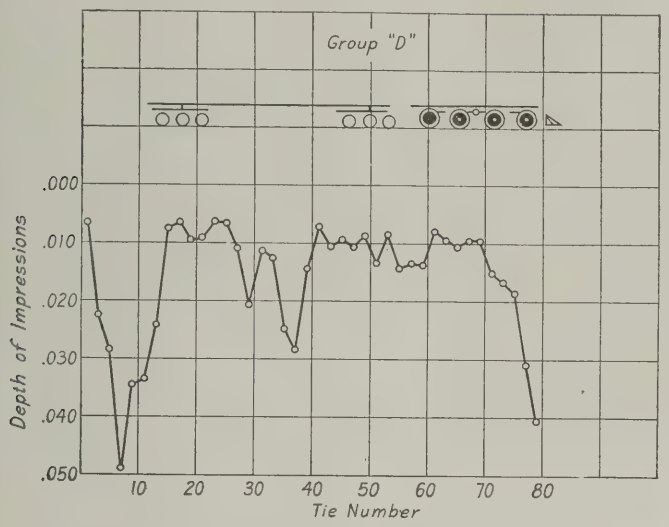


Fig. 14—Electric Locomotive No. 10,002, Speed 68.3 Miles Per Hour on Curve

The drives of Nos. 10,003 and 028 were very similar, consisting of a quill drive (type C).

Locomotive 10,003 was arranged for a.c. operation, which necessitated provision for d.c. control operation, which was placed in a separate car that always accompanied the locomotive.

Fig. 15—Tangent Track Kinked by Electric Locomotive No. 10,002

No. 028 was arranged with double control, a.c.-d.c., so as to facilitate its operation into Grand Central Terminal, New York.

Considered from various standpoints these locomotives ranked as follows:

As regards wheel-base:	Total wheel-base	Distance center to center of trucks
Electric locco. 10,003	20 ft. 7 in.	17 ft. 6 in.
Electric loco. 028	22 ft. 6 in.	14 ft. 6 in.
Steam, American type (4-4-0)	22 ft. 9½ in.	19 ft. 6 in.
Electric, 10,001 and 10,002	26 ft. 1 in.	17 ft. 7 in.
Steam, Atlantic type (4-4-2)	30 ft. 9½ in.	
Steam, Atlantic type (4-4-2)	30 ft. 9½ in.	

As regards center of gravity:	Vertically	Longitudinally
Electric loco. 10,002	42½ in. above rail	3½ in. from center
Electric loco. 10,001	45¼ in.	Centrally
Electric loco. 028	55 in.	Centrally
Electric loco. 10,003	55 in.	1 in. ahead of front drivers
Steam, American type (4-4-0)	63 in.	10¼ in. ahead of front drivers
Steam, Atlantic type (4-4-2)	73 in.	41¼ in. ahead of rear drivers

Thus, if length of wheel-base is to govern, the Atlantic type steam locomotive is the best, and the American type electric, 10,003, should be the worst. If height of center of gravity is to be the deciding factor, the Atlantic steam locomotive is still the best, and the articulated quill-drive electric 10,002 the worst.

As the object of the trials was to determine stability at express speeds, very few of the runs were made at lower ones, but it is fair to say that with any type of locomotive, steam or electric, not much disturbance should be expected at low speed, consequently progressive speeds were selected up to the maximum speed capacities of the various locomotives.

Fig. 16—Spikes Bent as Result of Lateral Impact on Tangent Tracks

Results of Tests

The runs with the steam locomotives went off very smoothly. Typical records are shown at different speeds for each type (Figs. 11 and 12). The maximum speed for the 4-4-0 type was 83 miles per hour, and for the 4-4-2 type, 95 miles per hour. It is not to be understood that these are practical operating speeds.

When the electric locomotives were run the story was very different, as will be seen from the diagrams (Fig. 13). The record for the geared locomotive, 10,001 (type B), shows severe oscillation with either end leading, there being three rather pronounced peaks at about the same space interval.

The maximum depth of impressions would indicate a lateral severity about double that with steam locomotives. It is probable that had the ties been arranged to record impressions at each end, intermediate impacts would have been shown on the opposite rail.

With 10,002, articulated quill drive, the records both

of depth of impressions and of the seismograph were decidedly the worst of all the locomotives under trial (Fig. 14). While runs were being made with this locomotive the tangent approach track began to spread, with results shown in Fig. 15. The greatest spread was 7/8-in. which caused kinking of the rail and bending of the spikes as shown in Fig. 16. The same thing happened in varying degree where runs were made with different locomotives coupled together, but only when locomotive 10,002 happened to be one of the combination.

With the non-articulated locomotive, 028, the readings both of the impressions (Fig. 17) and of the seismo-

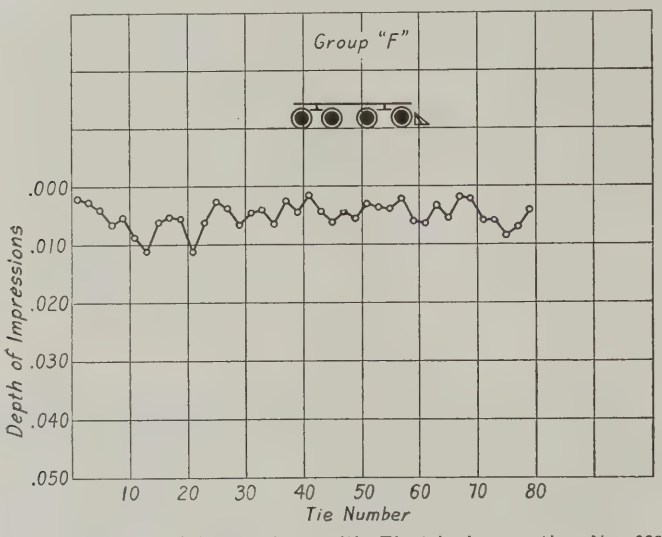


Fig. 17—Record of Impressions with Electric Locomotive No. 028 on Tangent, Speed 88.3 Miles Per Hour

graph showed a very much better performance, and so far as this set of tests went, the locomotive could not be considered bad. It was, however, tried only on the tangent track after the completion of the tests on the curve. The subsequent history of this type of locomotive in service showed that as wear accumulated the lateral oscillation became serious, so much so that the locomotives were changed by addition of a third carrying axle to each truck, thus forming a non-symmetrical arrangement and at the same time providing a longer wheelbase. It is probable that the smoothness of the diagram for this locomotive was largely due to the absence of end play of the axles in their boxes.

The last of the electric locomotives, 10,003, was in fact an eight-wheel American-type locomotive, and the records on both curve and tangent at once put it in the class of the best steam locomotives (Fig. 18). As originally constructed the leading truck had free lateral motion, and an extensive set of runs in both directions showed that while the free swing was an advantage when the truck led, it was a disadvantage when it trailed, and

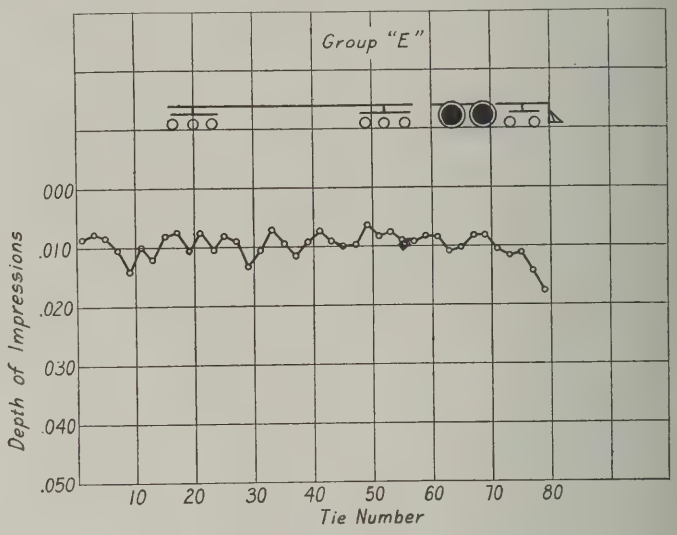


Fig. 18—Record of Impressions with Electric Locomotive No. 10,003, Speed 82.6 Miles Per Hour

that the best compromise was with truck rigid laterally.

These Franklinville tests concluded with runs of different combinations of locomotives coupled together. Apparently when the locomotives were coupled, the number of impressions was increased without material increase in the depth.

It appeared that in all combinations, including the articulated quill-drive locomotive 10,002, the riding of the companion locomotive was worse than when operated by itself.

The influence of the approach track had a very marked effect on the results. It was evident that for best results the recording track should have been very much longer to record the resonant type of oscillations from their origin through their development to the final dampening. It was evident that ties should have been arranged to record on each end.

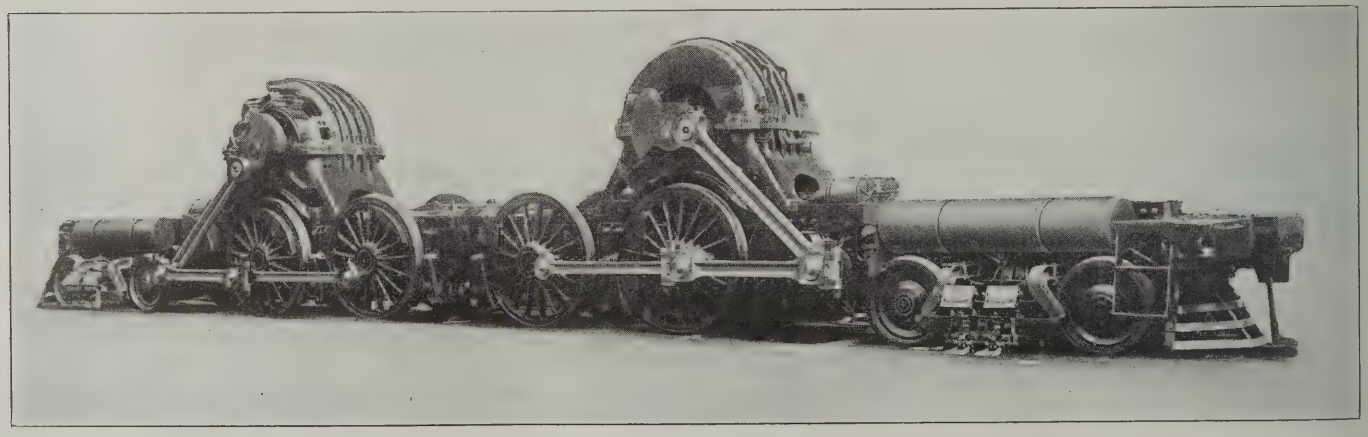


Fig. 19—Chassis of Electric Locomotive Finally Adopted

The severity of the impacts from the impressions measured statically is indicated by the following notes on rail pressure at speeds above 60 miles per hour:

GROUP A—STEAM LOCOMOTIVE
No. 6034, Type D-16b (4-4-0)

Maximum readings of 6 runs, speeds between 60.07 and 83.2 M.P.H.
At 60.07 M.P.H.—Impression .0135 in.—Pressure 7,250 lb.
At 80.0 M.P.H.—Impression .0141 in.—Pressure 7,580 lb.
Average—74.3 M.P.H.—Impression .0123 in.—Pressure 6,610 lb.

GROUP B—STEAM LOCOMOTIVE
No. 6020, Type E-2 (4-4-2)

Maximum readings of 7 runs, speeds between 59.6 and 95.7 M.P.H.
At 71.2 M.P.H.—Impression .0129 in.—Pressure 6,930 lb.
At 80.8 M.P.H.—Impression .0159 in.—Pressure 6,550 lb.
Average—74.4 M.P.H.—Impression .0123 in.—Pressure 6,500 lb.

GROUP C—ELECTRIC LOCOMOTIVE No. 10,001
Forward, No. 2 End Ahead

Maximum readings of 6 runs, speeds between 61.1 and 71.3 M.P.H.
At 71.3 M.P.H.—Impression .0272 in.—Pressure 14,620 lb.
At 67.9 M.P.H.—Impression .0193 in.—Pressure 10,370 lb.
Average—64.5 M.P.H.—Impression .0165 in.—Pressure 8,870 lb.

Reversed, No. 1 End Ahead

Maximum readings of 4 runs, speeds between 60.9 and 70.1 M.P.H.
At 62 and 70.1 M.P.H.—Impression .0289 in.—Pressure 15,530 lb.
At 69.7 M.P.H.—Impression .0298 in.—Pressure 16,000 lb.
Average—65.7 M.P.H.—Impression .0267 in.—Pressure 14,350 lb.

GROUP D—ELECTRIC LOCOMOTIVE No. 10,002

Maximum readings of 4 runs, speeds between 60.8 and 68.1 M.P.H.
At 62.8 M.P.H.—Impression .039 in.—Pressure 20,960 lb.
At 66.0 M.P.H.—Impression .0311 in.—Pressure 16,720 lb.
Average—64.4 M.P.H.—Impression .0291 in.—Pressure 15,640 lb.

GROUP E—ELECTRIC LOCOMOTIVE No. 10,003 (4-4-0)
Forward, Bolster Free

Maximum readings of 8 runs, speeds between 60.8 and 88.3 M.P.H.
At 63.3 M.P.H.—Impression .0123 in.—Pressure 6,610 lb.
At 72.38 M.P.H.—Impression .0125 in.—Pressure 6,720 lb.
Average 74.1 M.P.H.—Impression .0113 in.—Pressure 6,070 lb.

Forward, Bolster Blocked

Maximum readings of 6 runs, speeds between 60.0 and 83.9 M.P.H.
At 75.1 M.P.H.—Impression .0179 in.—Pressure 9,620 lb.
At 83.9 M.P.H.—Impression .0193 in.—Pressure 10,370 lb.
Average—73.5 M.P.H.—Impression .0149 in.—Pressure 8,010 lb.

Reversed, Bolster Blocked

Maximum readings of 6 runs, speeds between 60.0 and 83.9 M.P.H.
At 65.5 and 70 M.P.H.—Impression .0115 in.—Pressure 6,180 lb.
At 68.2 M.P.H.—Impression .0117 in.—Pressure 6,290 lb.
Average—74.04 M.P.H.—Impression .0106 in.—Pressure 5,700 lb.

Reversed, Bolster Free

Maximum readings of 5 runs, speeds between 60.4 and 77.5 M.P.H.
At 68.9 M.P.H.—Impression .0289 in.—Pressure 15,530 lb.
At 70.2 M.P.H.—Impression .0281 in.—Pressure 15,100 lb.
Average—68.9 M.P.H.—Impression .0236 in.—Pressure 12,700 lb.

GROUP F—NEW HAVEN ELECTRIC LOCOMOTIVE No. 028

Maximum readings of 9 runs, speeds between 60 and 88.3 M.P.H.
At 70.7 and 72.6 M.P.H.—Impression .0197 in.—Pressure 10,370 lb.
At 70.8 M.P.H.—Impression .0180 in.—Pressure 10,000 lb.
Average—71.7 M.P.H.—Impression .0149 in.—Pressure 9,000 lb.

The outstanding fact seemed to be the superior performance of the locomotive with the non-symmetrical wheel arrangement over that with the double four-wheel motor-driven trucks. The articulated truck arrangement was undoubtedly the worst of the combinations, but how much was due to low centre of gravity and how much to the articulation setting up a snaking motion was not definitely shown.

It is to be noted that one of the double-truck motor-driven locomotives and one with two driven axles and leading truck had the same height of centre of gravity, and the latter arrangement was decidedly the better. The comparison is the more interesting because in both of these locomotives the same quill-drive type is used.

The action as the result of the tests was the condemnation of both types of articulated electric locomotives and the preparation of an entirely new design.

The new design consisted of two eight-wheel American-type locomotives coupled back to back, each driven by one motor in the cab and coupled by cranks and rods to a jack-shaft placed in the horizontal axis of the driving wheels, and coupled to them by rods, as in this case of steam locomotives (Fig. 19). In this design were embodied not only the non-symmetrical wheel spacing of each semi-unit, but also the elevation of the centre of gravity of the spring-borne portion. This design was completed and locomotives built and tested in time to start the operation of the New York terminal in 1910, and the locomotives have satisfactorily performed that service ever since.

It is not claimed that the question of stability is fully understood. The selection of available wheel arrangements was very limited, but prompt decision was imperative. It is felt that this investigation should be considered as only a starting point for a much more extensive one, which should determine the most desirable arrangements of wheels, of height of centre of gravity, and method of motor drive.

So far as this particular investigation was concerned, the question of electric system was not involved, but, of course, a full discussion of the characteristics of steam and electric locomotives cannot ignore such questions.

Since this set of tests with single-ended ties, other series have been made in which the ties were arranged to record at each end. More ties were used so as to lengthen the test track. As for the equipment, the test included different methods of coupling the semi-units or electric locomotives; also studying the effect of depressions purposely placed in the approach track, the effect of different amounts of end clearance in the axle boxes, variation in the amount of counterbalancing in steam locomotives, etc. The whole accumulation of data is too voluminous to be included in one paper. Although considerable practical information of value has resulted from the various trials, there is much work yet to be done before the questions of stability are really understood. It is to be regretted that the selection of electric locomotives did not include greater variations in the wheel-base, the method of articulation and height of centre of gravity, but it is believed that the work already done is a very good starting point for future investigations.

Flexible Joints for Headlight Turbine Steam Lines

THE steam supply pipe between the cab and headlight turbine is subject to considerable vibration which has resulted in the pipes breaking off where they are screwed into the turbine. In order to eliminate this trouble a number of roads have adopted the practice of

Two Types of Flexible Joints

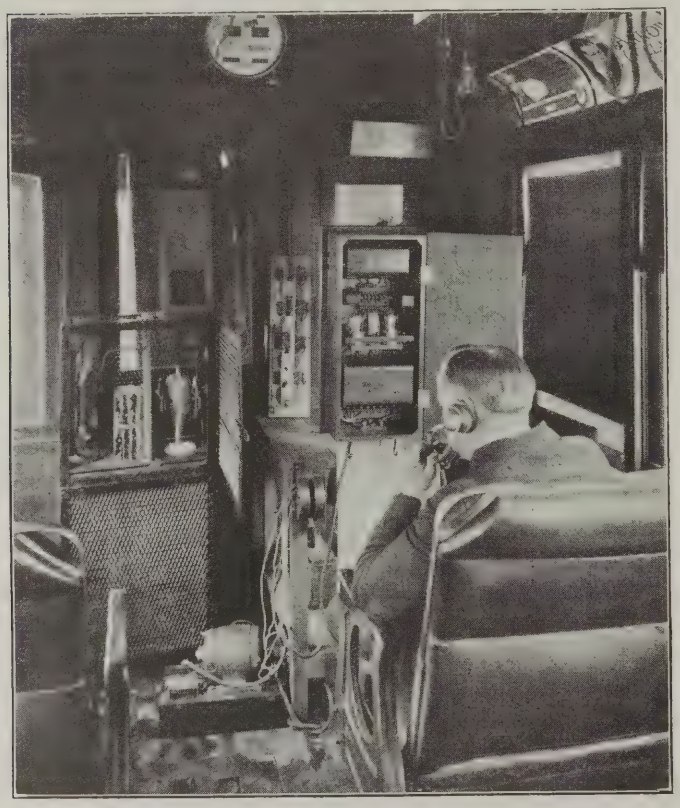
using flexible steam line joints in the turbine steam line with most satisfactory results. For this purpose flexible joints, made by the Barco Manufacturing Company, Chicago, have been used. These joints are used in sizes of ½ in., ⅜ in., 7C-8 or 7C-8B, according to the type of turbo-generators used and the direction of the pipe at the turbine.

"Carrier Current" Communication System Demonstrated

A group of prominent technical experts representing the New York Central and Pennsylvania Railroad systems witnessed a demonstration of what is known as the "carrier current" system of communication, at Schenectady, on December 1. These tests were the culmination of development work extending over a period of ten years, followed by practical tests made on the Chicago, Milwaukee & St. Paul Railway, where communication was effected up to 60 miles.

The system makes use of a second current superimposed on the same trolley wire which supplies current to operate the car. This "carrier current," which is generated at higher frequency than the power supply, serves to transmit messages along the wire, from which it is picked up at any convenient point and made to energize a telephone instrument.

The demonstration took place on the Schenectady Railway, five miles from the city, and was arranged by the Railway Department of the General Electric Company, which is interested in the development of the new system.



Using "Carrier Current" Communication System During Recent Tests at Schenectady

From the moving trolley car the railway men were enabled to talk successfully with a substation on the line several miles distant, and also to listen to conversation from the operator in the station. The second feature of the demonstration was listening to the conversation of the substation attendant at a waiting room two miles from the substation, the messages being transmitted over the trolley wire and amplified in the waiting room by a loud-speaking telephone instrument.

The demonstration was designed primarily to show the application of the system to communication on electric railways, especially as regards expediting train operation. It was developed particularly to afford an effective means of communication between the head and rear ends of long freight trains and to prevent "pulling draw bars." Experience with the system on the St. Paul, where it has been given exhaustive tests, shows it to be well adapted to communicating ahead of trains stalled by a faulty block. Use of the system on a single track portion of the St. Paul cleared up a misunderstanding on signals and saved an hour or two time, the loss of which would have been caused by having to send the flagman ahead to the next block. These previous tests in the West which were carried out by J. H. Payne, Jr., of the General Electric Research Laboratory, proved the practicability of the system and pointed to large benefits to electrified roads or to those which in future may become electrified. Communication on the St. Paul was effected up to 60 miles.

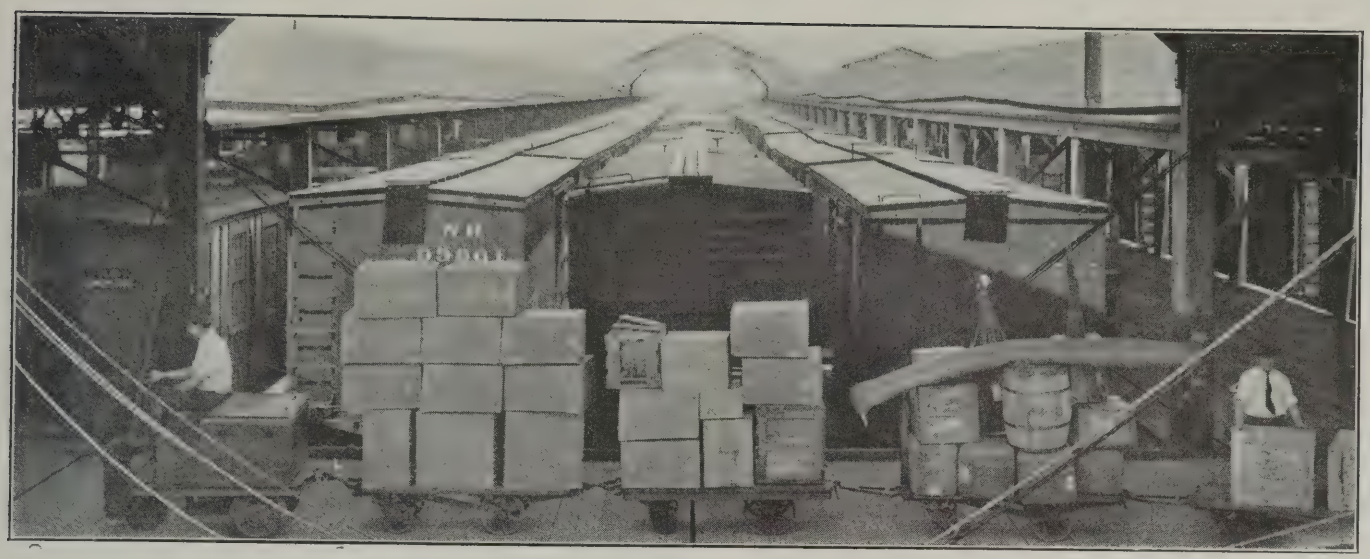
The apparatus used for carrier current communication is small and simple of operation. It consists essentially of vacuum tubes used as oscillators, rectifiers and detectors, making up a telephone equipment equaling in sensitiveness and simplicity the most modern apparatus.

Commenting on the tests, W. B. Potter, engineer of the Railway and Traction Department of the General Electric Company, said:

"These tests at Schenectady and on the C. M. & St. P. Railway indicate the early perfection of a practical telephone system utilizing the power wires as a conductor, which will provide for the usual call and telephone communication between different locomotives in the same train, the locomotive and caboose at the rear of the train, or communication between different trains. This system is equally applicable to communication between the train dispatcher and the trains in operation under his direction. This is an important development which we feel sure will contribute materially to the facility and safety of railway operation.

"The locomotive engineer on the head locomotive of a long freight train will be able to tell the engineer of the pusher at the rear when he is ready to start without resorting to 'bumping' the rear locomotive through the long train as is sometimes necessary when the present whistle signals are not audible. The train conductor can communicate with his engineer in case of anything happening to his own train which the engineer is not in a position to observe. The engineers of different trains on the same track can communicate with each other, which would greatly lessen the liability of train collision. While train orders will continue to be issued as a matter of record, they will not be beyond countermand by the train dispatcher in case of an emergency. The train dispatcher could in fact stop every train on his division should occasion require."

Twenty-six People Killed, 190 injured and 586 automobiles destroyed is the grade crossing record on the Southern Pacific for the past nine months. Nearly 300 drivers ran in front of or tried to beat the train to the crossing; 126 ran into trains, instead of trains striking them; 76 stalled on the track, largely the result of waiting until on the track before shifting gears; 55 ran into and broke down crossing gates; 28 approached the track at high speed, and five ran down and injured crossing flagmen.



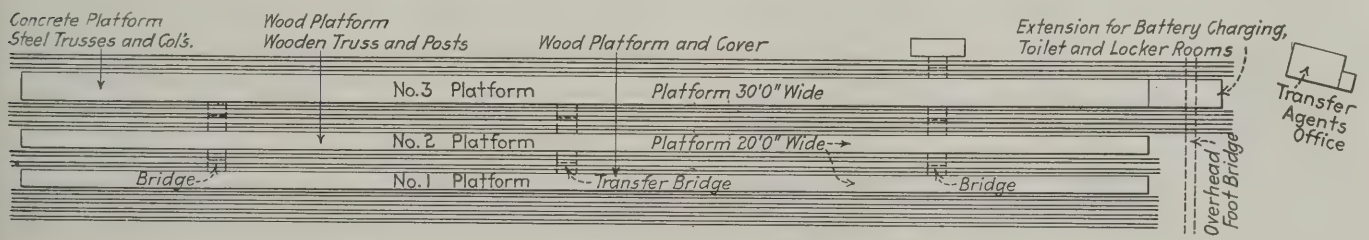
A View of One of the Three Lift Bridges

Electric Tractors in Freight Transfer Service

New Haven Road Effects Important Economies by Using Electrical Equipment in Handling L. C. L. Shipments

TWO important transfer stations, having a combined capacity for handling approximately 25,000 tons of merchandise freight monthly, have been closed permanently by the New York, New Haven & Hartford, and freight houses at eight originating points on its western lines have been relieved, in a large degree, of the necessity of carrying on transfer work as a result of opening for business new freight transfer facilities at Cedar Hill, New Haven, Conn.

In addition to the important economies effected in the entire freight transfer business on the west end of the New Haven, through the concentration of eastbound merchandise cars at one point, made possible by the new facilities at Cedar Hill, the new transfer is of particular interest because of the modern electrical equipment used in its operation.



Layout of Cedar Hill Transfer

Concentration of Cars Made Possible

Before the opening of the Cedar Hill transfer eastbound merchandise cars received by the New Haven via the Harlem river gateway were handled at the Westchester, N. Y., transfer as far as the limited facilities at that point would permit. Cars received in excess of that plant's capacity were sent further east, either to the Bridgeport, Conn., or the New Haven transfer. Similarly eastbound cars received via the Maybrook, N. Y., gateway were handled at Maybrook transfer.

Westchester transfer was operated under the gang and hand truck system and handled from 15,000 to 20,000 tons of merchandise freight a month. Because of the diversity of destinations, and the lack of sufficient tonnage to warrant direct cars to destination, a large amount of freight handled there received a secondary transfer, east. The gang and hand truck system was also followed at Maybrook. Less freight was received at that point than at Westchester and it was not practical to make up the direct-to-destination cars which good service demands.

By centralizing the cars received through both gateways at Cedar Hill, a direct-to-destination classification was made possible for approximately 75 per cent of the freight handled there, thus insuring better service from the standpoint of time, and reducing the number of cars required for the service, as well as the loss and damage resulting from a transfer of freight en route.

In addition to the Westchester and Maybrook plants, the road operated transfer plants at Bridgeport, Conn., and New Haven. These transfers accommodated approximately 100 cars each. Smaller transfers were operated at Danbury, Waterbury, Hartford and Putman,

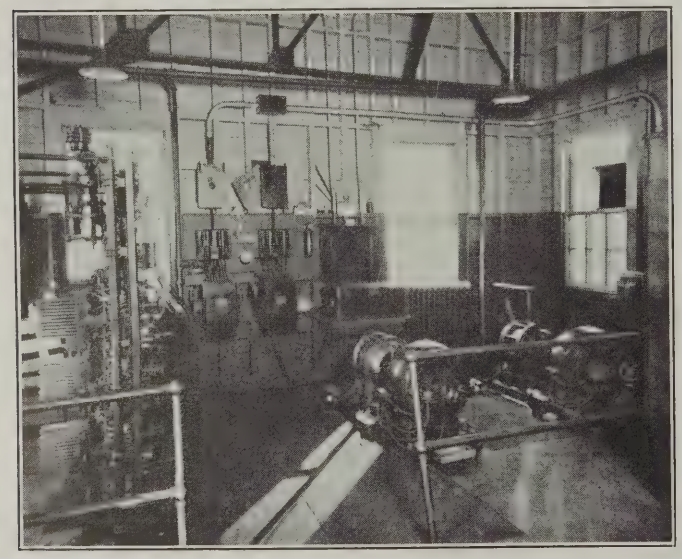
Conn.; Springfield, Mass., and Poughkeepsie, N. Y. Because of the small tonnage handled at these points only a limited number of classifications could be made and, in many instances, a second transfer was required before freight could be delivered at destination or to a connecting line.

All of the transfers mentioned, except Westchester and Maybrook, were in cities originating a considerable local tonnage and the local and the transfer plants were combined. As a result, delays to either the local freight or freight in transit were frequent.

Cedar Hill transfer was opened in July, 1920. One hundred and thirty-one distinct classifications are made daily and as many as 305 cars have been worked in one day, a normal daily performance being between 260 and 285 cars. The ability of the transfer to work this number of cars, with tractors and trailers, has resulted in the closing of the transfers at Westchester and Maybrook permanently. Furthermore, approximately 80 per cent of the transfers at Bridgeport and Hartford and 50 per cent of the transfers at Waterbury, Danbury and Poughkeepsie, have been eliminated through the concentration of the transfer business on the west end of the line. In addition, the Cedar Hill plant handles business diverted from all of the other transfers mentioned.

Platforms and Supporting Tracks

Cedar Hill transfer and its supporting tracks are located approximately in the center of the Cedar Hill yard, between the humps serving the westbound and the north and eastbound classification yards, in a location convenient for the receipt of cars from the various New Haven lines converging at Cedar Hill and for the delivery of northbound cars to the various points from which trains depart.

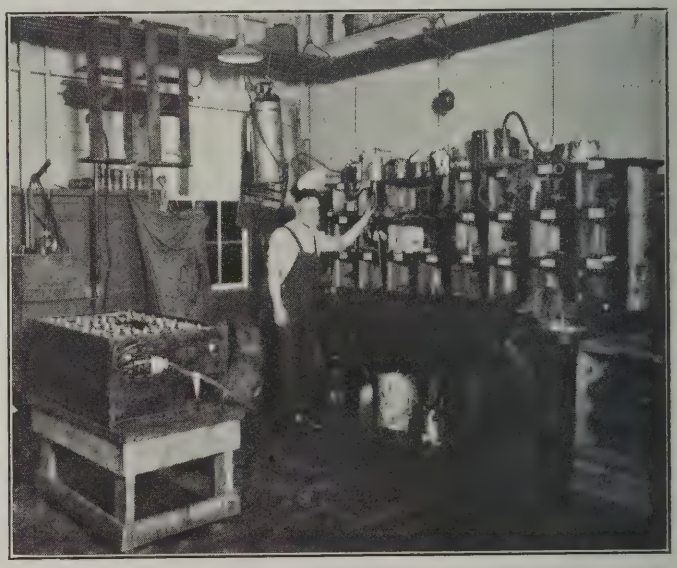


Motor-Generator Sets, Compensators and Control Switchboard for Charging Tractor Batteries

The layout includes 11 tracks and 3 platforms. Beginning at the east, platform No. 1, which is 20 ft. wide, separates the four outside tracks, which are numbered consecutively, A, B, 1 and 2, from tracks 3 and 4. Platform No. 2 is also 20 ft. wide and is located between tracks 3 and 4 and tracks 5, 6 and 7. Platform No. 3 is 30 ft. wide and separates tracks 8 and 9 from tracks 5, 6 and 7.

Each platform is 1,200 ft. long. Platform No. 1 is of wood construction and is covered with an umbrella shed roof with the posts located in the center of the platform. Platform No. 2 is also of wood construction and is covered with a hip roof with the posts placed on the edges of the platform. Platform No. 3 is of concrete and steel construction.

Three lift bridges, 20 ft. wide, are provided between the platforms; the first bridge is located 200 ft. from the north end of the platform, the second 600 ft. from the north end and the third 200 ft. from the south end. The bridges serve as the main line route between platforms for loaded trailers and trucks while the door-to-door method of spotting cars provides for disposing of trailers after they are made empty without interference with oncoming loads.



All Truck Repair Facilities Are Located in One Corner of the Charging Room

An extension of 40 ft., on the platform level, at the north end of platform No. 3, provides space for a charging station and a repair shop for the tractors, as well as for toilets and washrooms for the laborers. Individual lockers, benches and tables for the laborers are in the basement of the extension. This space is also used for a rest-room during lunch hour.

With the exception of the outside tracks 8 and 9, where space is available for 29 cars, each track accommodates 27 cars. Taken together, the supporting tracks provide capacity for the total of 300 cars which constitutes the daily set-up.

The Car Set-Up

Empty cars are placed on tracks 3, 4, 5 and 6 and all other tracks are used for loaded cars. By referring to the plan showing the transfer layout it will be seen that, by this arrangement, the center platform becomes what might be termed a loading platform with two tracks for empty cars on each side. This permits the freight to be trucked from the loaded cars over the lift bridges and the center platform to the proper destination car and allows a quick return of the empty trailers to the working platforms Nos. 1 and 2; the trailers, after the unloading is done, are pushed out of the cars onto the outside platforms by the stevedores.

Six of the tracks, 3, 4, 5, 6, 7 and 8, as well as 17 cars on track 2, are devoted to standard classification daily. The set-up on these tracks is arranged in station and train order so far as the length of the tracks permit. As previously mentioned, tracks 2, 7 and 8 are set-up daily with loaded merchandise cars. Therefore it is evident that 17 cars on track 2 and all the cars on tracks 7 and 8 must be made empty and reloaded daily in following the standard classification. In addition to the cars of the

Tractors with Trains and One Running Light

standard set-up, direct-to-destination cars and overflow cars are loaded on the working tracks A, B, 1 and 9, as conditions require; or, in other words, in taking care, each day, of merchandise from the cars which are released.

The standard classification provides for merchandise cars to be made daily for 131 different points. In several instances, however, more than one car for a destination is required. These are, of course, loaded in series on the

A General View of the 30-Ft. Concrete Platform

same track, preserving the station and train order so that at the close of each day's work they can be moved forward without delay. For instance, the daily tonnage for Boston and for Providence is sufficient to warrant a regular assignment of 10 cars for each of these cities. More than 131 cars are, therefore, required daily to fulfill the car requirements of the standard classification. Actually, the number of cars required for this purpose is usually in excess of 200 cars. Including the overflow cars and the direct-to-destination cars, the total number of merchandise cars forwarded daily is approximately 225.

Rapid Handling and Low Costs

The platform equipment used at the transfer includes 13 Elwell-Parker electric storage battery tractors and one Mercury tractor; 485 four-wheel trailers of various types, a majority of which are equipped with Hyatt roller bearings or ball bearings; 132 two-wheel hand trucks and 6 dolly or machinery trucks. The Elwell-Parker tractors are known as the type TA. They are of the three-wheel construction with single reduction worm drive—having three speeds forward and three reverse. The steering handle is arranged so that it can be used either right or left handed as desired. The normal draw-bar pull of these tractors is 300 lb., which can be increased on occasion to a maximum of 1,300 lb. The speed at no load is 7½ miles per hour. One of the special features of this tractor is the interconnection between the seat and the control apparatus. When the seat is unoccupied it is tilted forward by the tension of a spring and when in this inclined position it is impossible to move the tractor by the operation of the control lever. Moreover, should

A General View of the Transfer

the driver leave his seat for any reason while the tractor is in motion, the control connection would be immediately broken and the tractor would stop. In normal operation, slowing down is accomplished through the action of an external contracting brake operated by a foot pedal located in the floor in front of the driver.

With the exception of short haul shipments, liquids in barrels and single package shipments too heavy to be loaded economically on flat trucks, all transferring is done with tractors and trailers. To secure the full value of the tractors, three-wheel "tip-up" trailer trucks have been ordered. When they are received the heavy packages and liquids in barrels will also be moved by the tractors and trailers.

During the month of August, 1921, based on an 8-hr. day, the transfer was operated with 306 employees per day as follows: 1 general foreman; 3 foremen; 10 office men; 3 inspectors; 43 tallymen; 93 loaders and stevedores; 146 truckmen; 1 cooper; 1 car cleaner; 1 car sealer; 1 watchman; 2 battery chargers, and 1 messenger; a total of 306 men. Twenty-eight of the truckmen work on the tractors, either as operators or helpers.

Including all money paid to all the employees listed, and excluding the "no credit" tonnage which is not considered in arriving at the cost of handling, the average cost per ton of freight handled during the month was $0.669.

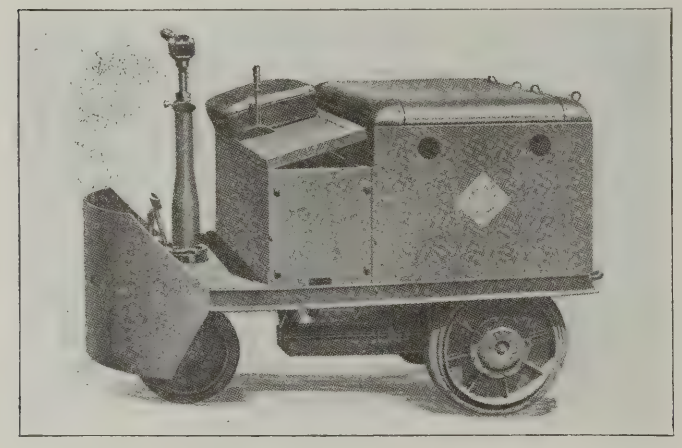
With this force a total of 5,745 merchandise cars were forwarded out of the transfer during August, a daily average of 221 cars. During the same month 6,408 loaded cars were received and unloaded, an average of 246 cars per day. The average daily tonnage handled was 1,849 tons; in addition, 1,334 tons of "no credit" tonnage moved out of the terminal in the original cars during the month.

The results of the tractor and trailer system of operation have been gratifying. Much more tonnage per man is handled at Cedar Hill than at the transfers operated under the gang and hand-truck system which it has largely superseded. The increase in tonnage handled per man has resulted in a decrease in the cost of handling.

Comparative figures between the operation of Westchester transfer—a two-wheel hand-power truck-operated transfer entirely—for the last month of its operation, June, 1920, and Cedar Hill for the month of May, 1921, disclose the fact that 7.542 tons per man per 8-hr. day were moved at Cedar Hill as compared with 4.454 tons at Westchester, an increase of 69 per cent.

Battery Charging and Tractor Maintenance

Tractor maintenance, including the charging of the tractor batteries, is a comparatively simple matter, requiring the services of only two men and one room about 30 ft. wide and 20 ft. long at one end of the 30-foot platform. About one-third of this room is occupied by two



Elwell Parker Type TA Three Wheel Tractor

small motor-generator sets and the necessary switching apparatus, and the remainder is used for tractors and repair facilities.

One of the maintainers goes on duty at four o'clock in the afternoon, just after work on the platforms has stopped. Eight of the tractors are run into the charging and repair room and placed on charge. Each truck is equipped with a battery consisting of 30 Edison cells and they are charged at the 8-hr. rate, which insures their being fully charged before midnight. Charging is discontinued when the no-load voltage reading is 52 volts. The second maintainer relieves the first at midnight and has the remaining six tractor batteries charged before work is again started in the morning.

Two motor-generator sets supply all of the charging current. The two are identical and each set consists of a 75-volt, 240-ampere direct-current generator driven by a three-phase, 440-volt, 30-hp. induction motor running at 1,800 r.p.m. There are two charging panels in the switchboard and each one is equipped with a circuit breaker having an overload trip and no-voltage release, a grid charging resistance, an ammeter switch and a voltmeter button. With this equipment the operator can control the rate of charge on each tractor separately and can determine the current and load or no-load voltage of any battery with one ammeter and one voltmeter. Occasionally some of the batteries are given a boosting charge at noon, but this is not often necessary.

The lubrication of the differential gear requires one-half gallon of oil per year for each tractor. The oil used for this purpose is made from the castor bean and possesses the advantageous property of a constant viscosity within the range of operating temperatures. It is to be preferred to grease, where it is possible to use it, as it works into the ball bearings better than the grease. It also forms an excellent lubricant for the case hardened worm in mesh with the bronze worm wheel. In addition to the castor bean oil, there are 11 grease cups on each tractor which require filling every 30 days.

The most important duties of maintenance are to keep the equipment clean and properly lubricated. The tractors are equipped with rubber tires, which are estimated to have a life of approximately two years for this particular installation.

The transfer is located on the New Haven division, E. E. Regan, superintendent, and is operated under the direct charge of J. B. O'Brien, agent, and under the general supervision of George Mark, assistant to the general manager.

The Australian Railway Commission recommends the 4 ft. 8½ in. railway gage. The estimated cost of the conversion by the roads using the narrow gage was estimated at $115,000,000 in 1913, but the estimate at present-day prices is expected to exceed $450,000,000. The state premiers will discuss the financing of the work.

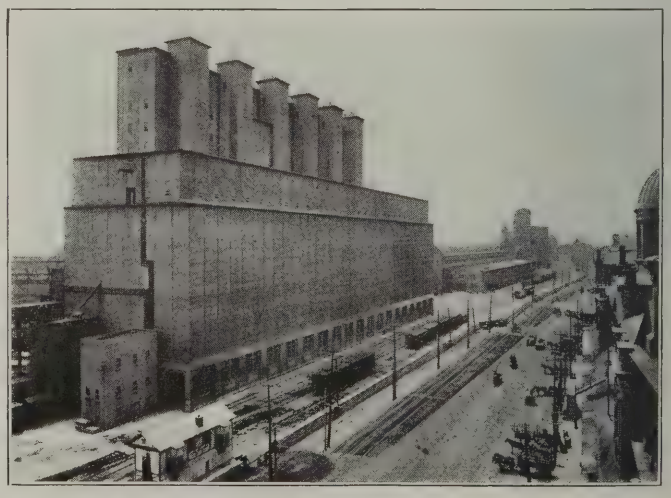


Photo by Keystone View Co.

Grain Elevator at Fort Williams, Ont.

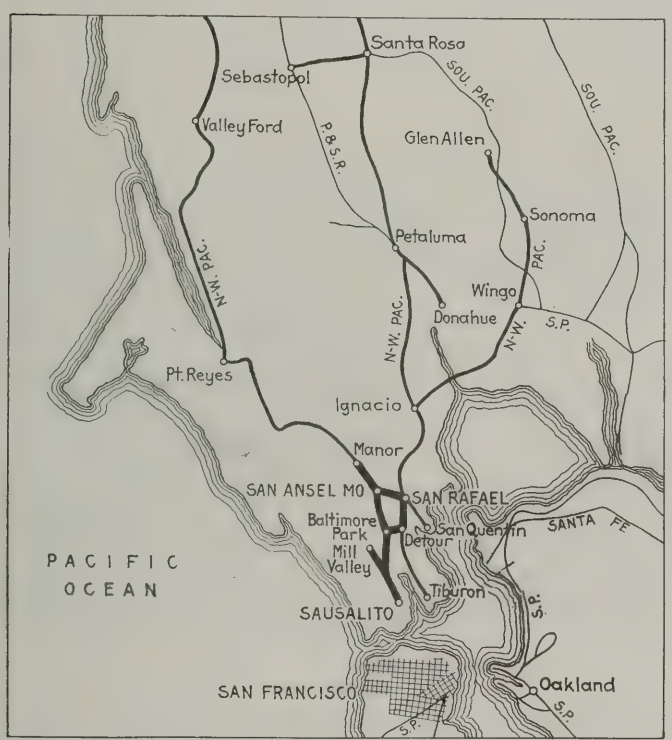
Third Rail Is Favored by Northwestern Pacific*

Feeder Is Clamped Into Web of Rail and Bonds Are Soldered—Maintenance Costs Are Low

OUR entire operation is over a private right-of-way, and therefore we will not enter into any lengthy discussion as to why the third-rail system was chosen instead of the overhead trolley. Those of us who today (after 18 years of service) have the responsibility for the up-keep of this system go to bed nights, yes stormy, windy nights, too, and sleep just as soundly as those men did who first installed it. Could you say the same for a man on a trolley system? I am afraid not.

Electrical Equipment

The original installation completed in 1903 consisted of the following: Sausalito to San Anselmo, double-track, 10 miles except C. M. tunnel. San Anselmo to San Rafael, single-track, two and one-half miles. Almonte to Mill Valley, single-track, two miles. Since then there have been electrified two other sections, Baltimore Park to San Rafael via Greenbrae, and from San Anselmo to Manor.



Map of Southern Part of Northwestern Pacific, Showing Electrified Sections

The present system consists of six miles of single-track and 15½ miles of double-track, or a total of 37 miles of electrified track.

The first installation of power equipment was the present power house at Alto, a storage battery at Sausalito, a storage battery at San Anselmo, and a small motor-generator set at San Rafael. The storage batteries have been eliminated, and we now have the power house at Alto with a capacity of 3,200 k. w. (combined steam and motor-generators) and a substation at San Anselmo with 1,500 k. w. in motor-generators.

All steam generation is 600-volt direct current. The motor-generator sets receive power from the transmission lines of the Pacific Gas & Electric Co., and deliver 600 volts d. c. to the third-rail. All stations carry 600 volts at the switchboard and that statement establishes our layout as a 600-volt system.

Experience with Third Rail Supports

The over-running contact rail as used on the Northwestern Pacific is all regular common "T" rail and nearly all of it is either 60-lb. steel or 50-lb. iron. As an electrical conductor these two kinds of rail are considered equal, and for practical calculations are equal in conductivity to 600,000 circular mil copper, nearly three times the ordinary trolley.

In the first installation the rail was supported mainly on a large block of wood spiked to the tie and the contact rail was spiked to the block. These were continually breaking off and did not last very long. Then some patent granite blocks were tried. These were put in at the Sausalito terminal and through the Corte Madera tunnel. The leakage over them was excessive and the aura at night was at times brilliant. It was quickly decided that the object to be obtained was a support for the contact rail and not a means of illumination. The granite blocks therefore found their way out.

At that time the present style of support block was designed and put into service and our troubles were nearly over. This type block has proven very satisfactory so far as the Northwestern Pacific lines are concerned. Every sixth tie in the track is one foot longer than the standard tie. On this extra length the support for the contact rail is placed. This support consists of a redwood block 5 in. square and 6½ in. or 7 in. long. The length depends on the size of rail in track. This block is treated with two coats of insulating paint by dipping. There is a ⅜ in. through bolt at the base holding to small angle irons which in turn are lagged to the tie. On top of the block is placed a cast-iron cap upon which the rail rests. The cap is so constructed as to form an apron over the block and give a space of nearly 2 in. on the block that is always dry even in the worst rain storms. This cast-iron cap has a channel in which the rail rests, the channel running parallel with the track. The rail is not clamped or fastened to the block in any way, but is free to move with the expansion and contraction.

One of the questions that probably comes to the minds of some is that this is not adequate and the contact rail should be held down. I am free to admit that we have had the contact rail try to crawl all over the right-of-way at times, but it generally landed on the running rail and the result was fireworks and a shut-down. When this buckling has occurred it is simply a case of breaking a joint, allowing the rail to straighten out and dropping the overlapped ends to allow safe travel of the collecting

*Abstract of a paper read at the Pacific Railway Club's fifth annual electrical night by C. E. Hatch, electrical engineer at San Francisco.

shoe on cars. This has always happened during the warm hours of the day and by morning the men could go out and place the rails back on the blocks and bolt them together. To overcome this trouble, about twice a year men go over the line and hammer the joints and pour oil around the angle bars and over a large proportion of the support block caps. When this has been properly done, the buckling feature has been eliminated. As an illustration of how successful this is, we have several sections of 3,000 ft. and one section of over 4,000 ft. continuous run of power rail.

Undergrounds for Road Crossings

At road crossings and intervals in front of stations, the rail is opened and the ends protected by approach blocks. These blocks are pieces of rail equal in cross-section to the contact rail, but with one end heated and hammered, thus allowing the contact shoes on the cars to ride up onto the rail easily. At these openings there is constructed an underground box with at least one 1,000,000 circular mil cable in it, the ends of which are soldered to the ends of the contact rail, thereby making the continuous circuit.

These undergrounds, as we call them, are constructed of one inch redwood and are made four inches square inside. The cable is supported in the box, clear of the wood by porcelain cleats overy two feet. The box is then filled with an asphaltum insulating pitch. The pitch is heated and is poured slowly to avoid blow holes and the cover of the box is nailed on while the pitch is still hot. Properly installed this type of box has proved very satisfactory and has the most excellent moisture resisting qualities. Many of these boxes after years of service have had the cables disconnected and careful tests showed not the slightest leak.

Feeders

In the original installation a feeder was used which was placed in the web of the rail from Sausalito to San Anselmo with the exception of the section through the Corte Madera tunnel. This feeder was a 1⅜ in. aluminum rod in 30 ft. lengths coupled together by compressed sleeve joints. At short intervals this rod was bent outward from the rail, a clamp with two copper cable wings was fastened to the rod and the ends of the cable soldered to the base of the rail, but it proved unsatisfactory. It was but a short time after its installation that the sleeve joints began to loosen up. To try and remedy this condition, the sleeve and rod were drilled through and aluminum pins driven in. These in time sheared off and then we were worse off than ever.

It was interesting to ride on the rear of a train in the morning and spot the bad joints in this rod. Everything would be damp from the fog of the night before except the bad joints and they would be dry, due to the heating of the metal from poor contacts. It reached a point where you needed to count pretty fast to get them all. We used to wonder sometimes just how much of the company's money we were spending to maintain those automatic driers. Our experiences with this rod were very interesting and our attempts to overcome the difficulty instructive, but sad. At openings where the rod ended it was necessary to use a long brass sleeve for connection. The rod was soldered in one end of the sleeve, using only pure block tin. In the other end was soldered a short piece of copper cable, using half-and-half solder and the cable soldered to the rail. This meant many additional and seemingly unnecessary joints, but it was the best and only satisfactory solution offered for handling the rod. We made an attempt to place copper jumpers around the joint in rod, along the rail, which appeared at first to be very successful. The jumpers were soldered directly to the rod on either side of the sleeves. There were about 75 of these joints put on in the section between Alto and Almonte. Upon going out there four days later, we found all the jumpers on the ground, having fallen off of their own weight. Another attempt to solder aluminum proved futile.

About five years ago, there came suddenly a demand for aluminum. Someone heard that we had this, took the whole lot off our hands and gave us one million circular mil copper cable in its place foot for foot. The change was made without expense to the railroad company. This was a great relief to all of us, not only from a purely engineering standpoint but also in a financial way as well. We now have good connections to the rail and a good joint in our feeder every 1,000 ft. where before we had a poor joint every 30 ft.

Our method of carrying feeders is a great advantage in the third-rail construction, both mechanically and financially. From Sausalito to Alto power house, a distance of 4½ miles, we have two one million circular mil cables on each rail, or four cables in all, and the only additional expense for feeder support is the small iron clamp used to hold the cable in the web of the rail. There are at advantageous points switches so that the system can be sectionalized if necessary and in case of trouble one section be eliminated entirely. We also carry an overhead jumper on pole line over Corte Madera tunnel, and have switches installed so that the tunnel section alone can be cut out without interference with any other section.

Soldering Bonds on the Running Rail. Third Rail Is Shown in Foreground

Third Rail Protection

At the stations in the double-track territory, there used to be a platform over both power rails. These center platforms have now all been discarded and platforms constructed on the outside. As a protection in lieu of the center platform there a wooden guard is placed over the power rail and a fence between them. This wooden

guard is a piece of 2 in. by 8 in. pine fastened to and supported by the power rail itself. This guard rail is used also in yards and other places where employees and others are liable to stumble over the power rail.

The use of a third-rail system, of course, can only be justified where, like the Northwestern Pacific, the operations are entirely over private right-of-way. There have been several cases where people struck by a train have been thrown against the power rail and burned. There is but one case of human life lost that I can find, directly traceable to contact with the third-rail.

Maintenance Costs

There can be naturally not much argument as to maintenance between the overhead trolley and the third-rail system. It will probably sound rather fishy to some trolley men to hear that for the past ten years our regular third-rail maintenance crew has not at any time exceeded five men. And these five men also find time to do part of the construction work of what extensions have been made during that time.

Our maintenance costs after 13 years of service show the following averages:

For 1916	$87.00 per mile
1917	95.00 per mile
1918	145.00 per mile

The differences in these costs do not reflect any change in the condition of the rails, but rather a decided change in labor and material cost. At present we are maintaining the entire system with a crew of five men, three of whom only devote one-half day to power rail work. This crew also does all track bonding.

All Bonds Are Soldered

The costs previously given take care of all track bonding. All joints on the running rail are bonded with a 300,000 circular mil soldered bond with a "T" head, soldered directly to the rail. We admit that we are without doubt cranks on solder. All joints of whatever nature, bonds, feeder cable, cross cables, are soldered direct to the rail, using half-and-half solder. Our results from this operation are satisfactory and we make in our cable connections but one joint, where with the lug method there are two joints, one where the cable is soldered into the lug and another where the lug is bolted to the rail. This method gives a much better electrical connection between rail and copper cable.

The gage of our rail is 26½ in. out from the gage line of track and top of power rail 6 in. above top of running rail. For total clearance we ask 12 in. above top of running rail, 22 in. out or more. This clears on all classes of equipment. Occasionally some large furniture car is sent on the road with unusually low truss rods, but this difficulty is overcome by observing the published clearances and also the alertness of car inspectors at Tiburon, where most of such equipment reaches our road.

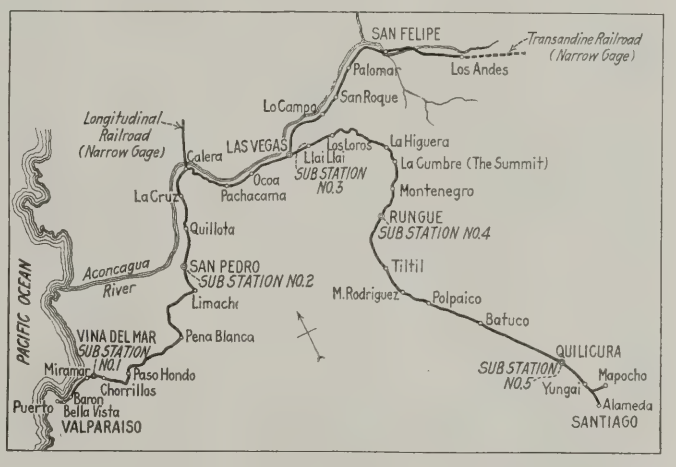
Effect of High Water

One of the main difficulties is in the winter from high water. We have had several times when at certain points the water was up over the power rail, but it was fresh water and we were able to keep power on the rail and keep trains moving. When the extreme high tides come in the winter along the shores of Richardson Bay with a good southwester behind them and the salt water begins to get up around the power rail, why, then we quit. This was particularly bad during one storm in the winter 1918-1919, and our traffic out of Sausalito was stopped for about three hours.

Chilean Railroad Electrification Program

THE first part of the Chilean State Railway to be electrified will include 116 miles of main line and 144 miles of track. The contract for equipment, as announced in the October, 1921, issue of the *Railway Electrical Engineer,* was awarded to the Westinghouse Electric International Company through its South American representatives, Errazuriz Simpson & Company, and amounts to a total of $7,000,000. This is the most important railroad electrification undertaken in 1921 and is the largest single order for electric traction equipment ever received in this country. The equipment will be designed according to American standards.

Chile is a long, narrow country located between the Andes mountains and the Pacific Ocean, on the west coast of South America. It is 2,629 miles long north and south, and varies from 100 to 250 miles in width. The extreme length of the country results in a variety of climatic conditions. However, in the section to be electrified at present, the variation between maximum and minimum temperatures conforms to normal conditions existing in the temperate zones, the maximum temperature in the shade in the summer being from 100 to 110 deg. F. and in the sun as high as 130 to 140 deg. F., while in the winter the temperature goes as low as 20 to 25 deg. F. The rainfall in this district is relatively small. In the central and southern sections the Andes receive a heavy snowfall, making extensive water power available.



Map of the First Zone to Be Electrified on the Chilean State Railways Showing Location of Substations

Chilean Foreign Trade Over $450,000,000

The chief products of Chile are minerals, agricultural products, live stock and lumber. Many of these products are exported and move north over the railroads. In return, coal, merchandise, machinery and food products are imported and form the bulk of the southward railroad movement. In Chile the nitrate deposits in the north rank first among the mineral deposits, and supply 75 per cent of the exports. In 1913, 3,000,000 tons were exported, Coal deposits ranked second to those of nitrates, but in spite of this fact, there is not enough coal to supply

the country, and considerable coal is imported. The present output of coal in Chile is 1,800,000 tons annually while the consumption is about 2,700,000 tons, the railroads using 550,000 tons. Copper is also an important mineral deposit, between 4 and 5 per cent of the world's supply coming from Chile. Iron, sulphur and gold are also mined.

Other industries in Chile are farming and some fishing. The variety of climate permits the growth of a great diversity of food plants, among which are tropical fruits, vegetables, and cereals, including wheat, barley, oats, rye, corn, beans, and peas.

The United States exports a great variety of materials to Chile, and our imports from Chile are also extremely varied in character. These include such items as chemicals, dyewoods, fertilizers, minerals, glue, india rubber, meat, tobacco leaf, wax and vegetables. In import trade to Chile the United States now ranks first and Great Britain second. Published statistics of Chilean foreign trade for 1920 show imports of about $166,100,000 and exports of about $284,300,000, a total of about $450,400,000. The total wealth of Chile is estimated at $3,200,000,000, or almost $800 per capita.

The Railroads of Chile

The total railroad mileage of Chile is 5,200, of which about 30 per cent is privately owned mainly for mining and industrial enterprises. The remainder of the mileage is divided into two general classes, the broad gage lines and the narrow gage lines. The former extend south from Valparaiso by way of Santiago to Paerto Montt, with numerous branches, while the latter comprise most of the northern roads with a few branch lines in the south.

The conditions that arose during the recent world war brought very forcefully to the attention of the railroad management the necessity for electrifying the broad gage lines, especially the Valparaiso-Santiago line with the Los Andes branch, where traffic was rapidly approaching the track capacity. In addition, fuel costs were excessive while the almost limitless water power was going to waste.

In 1918 a commission was appointed to study the problem of electrifying the broad gage lines. This commission, consisting of Rafel S. Edwards and Ricardo P. Solar, made a careful analysis of electrifications all over the world. As a result of the possible economies shown in the report of this commission, it was decided immediately to electrify the broad gage lines beginning with the Valparaiso-Santiago and Los Andes branches, or the first zone. A loan of $10,500,000 for this purpose was authorized and was heavily over-subscribed a few hours after offering.

The specifications called not only for locomotives to fit the traffic conditions but also for all substation, distribution and overhead equipment, and for all construction work.

Initial Electrification Will Include 144 Miles

The initial electrification will include 116 miles from Valparaiso to Santiago, and 28 miles from Las Vegas to Los Andes. Los Andes is the terminus of the Transandine Railroad, a narrow gage line, while the narrow gage Longitudinal Railroad runs north from Calera, an important station on the line to be electrified. The maximum grade in this zone is 2.25 per cent, encountered in approaching La Cumbre (the summit) from the west. The line contains a relatively large number of curves, the maximum being 10 deg. The track gage is 5 ft. 6 in. There are six tunnels on the main line, the longest, the San Pedro, being 1,600 ft. in length. Three of the tunnels are located on the most severe grade approaching the summit.

The 3,000-volt direct-current system was decided upon as best suited to the conditions. Hydro-electric power will be generated at the Maitines station of the Chilean Electric Tramway & Light Co., Ltd. This station is already under construction and will utilize the waters of the Rio Colorado. The station will contain three 8,125 kilovolt-ampere generators and will have an ultimate capacity of 30,000 kilowatts. This power will be transmitted 37 miles to Santiago by twin circuit 110,000-volt transmission lines and will be generated at 50 cycles, 3-phase. These transmission lines will be connected at Santiago with the system fed by the Florida hydro-electric station and the Mapocho steam station, both of which were constructed some years ago by the Germans and were designed for 50-cycle 3-phase power. The total capacity of the three generating stations at present proposed will be, when completed, approximately 120,000 kw.

Substations Provide for Large Increase of Traffic

The power supply will be distributed by five substations designed to handle a train movement that is approximately 50 per cent greater than that existing in 1917, with a further provision for tripling the 1917 traffic demands, if necessary. Each station will initially contain two 2,000 kw. motor generator sets, each set consisting of a 2,800-hp. driving motor, and two 1,000-kw. 1,500 volt generators connected in series. These sets will be designed to withstand a 200 per cent overload for five minutes without injury, and as an additional safeguard a flash suppressor will be included.

Substations 1 and 5 will receive power at 12,000 volts while 2, 3 and 4 will receive power at 44,000 volts and power indicating and limiting equipment will be installed.

Motive Power

Thirty-nine electric locomotives are required for the initial electrification, including 6 express passenger, 11 local passenger, 15 road freight and 7 switching locomotives. The main points of interest about these locomotives are given in the following table:

Type locomotive	Weight, tons	Length, ft. in.	Wheel arrangement	Number of motors	Total h. p.	Max. speed, miles per hr.
Express passenger.	127	58 ft. 6 in.	2-6-0—0-6-2	6	2,250	62½
Local passenger...	80	40 ft. 6 in.	0-4-0—0-4-0	4	1,500	56
Road freight.....	113	49 ft. 10 in.	0-6-0—0-6-0	6	1,680	40
Switching	65	40 ft.	0-4-0—0-4-0	4	480	34

The express passenger and road freight locomotives will be equipped for regenerative braking. The service in which the local passenger locomotives will operate will not require or justify the regenerative braking feature.

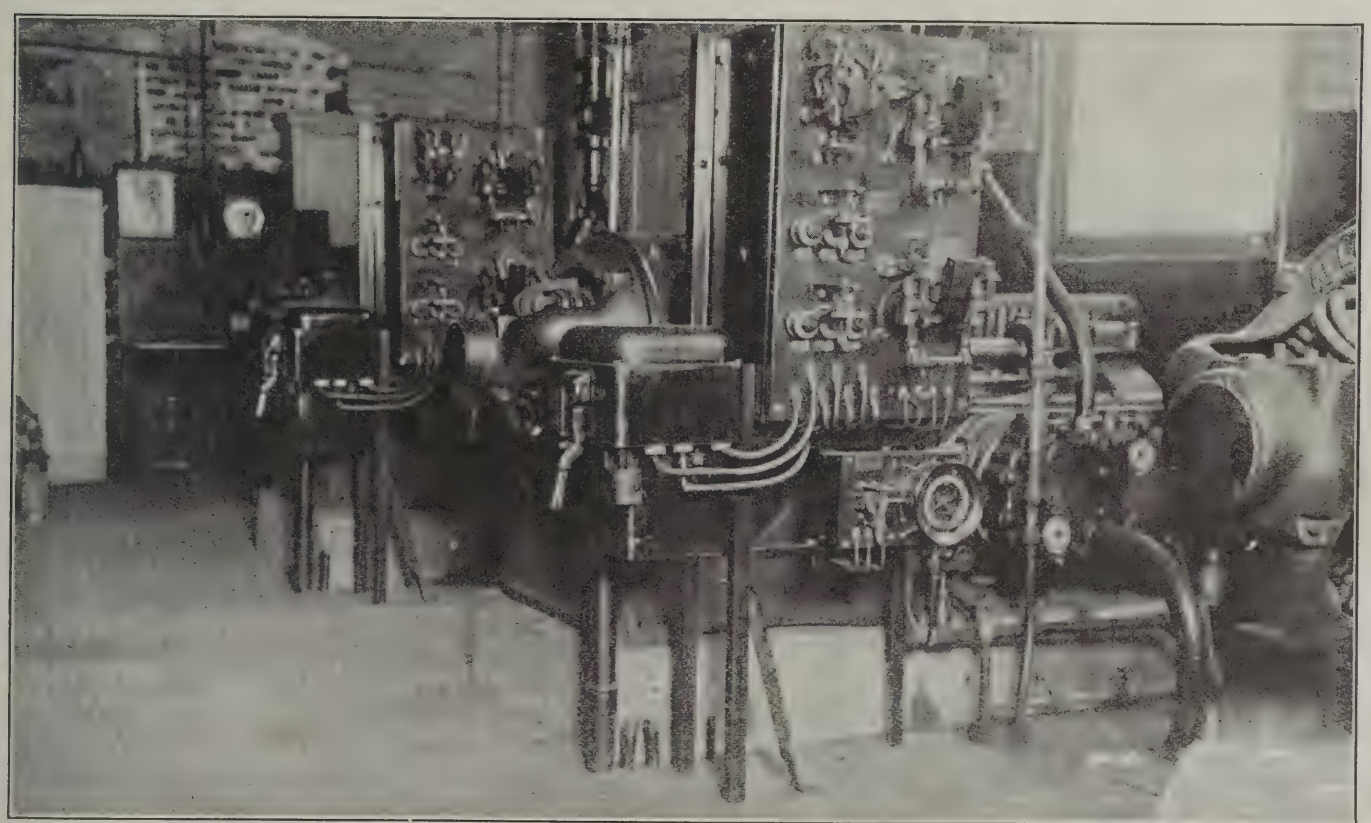
According to a statement issued by the Westinghouse International Company this contract includes only the first railroad zone of the electrification project which Chile has undertaken.

There are 740,000 miles of railways in the world, of which 266,000 are in the United States, 220,000 in Europe, 70,000 in Asia, 60,000 in South America, 30,000 in Africa, and 26,000 in Australia.

New Air Compressor Equipment on the C. & W. I.

Modern Electrically Driven Plant Replaces Steam Operated Units and Effects Remarkable Economies

AUTOMATICALLY controlled, electrically driven, air compressor units and motor generator sets have been installed recently at the old electro-pneumatic interlocking plant on the Chicago & Western Indiana at 21st street and Stewart avenue, Chicago. The new equipment completely replaces the old boiler and steam driven units. This interlocking situated at a junction of the Pennsylvania and Chicago & Alton, Illinois Central, Santa Fe and Chicago & Western Indiana was constructed in 1893. Trains of the C. & E. I., Monon, Grand Trunk, Wabash, Erie and C. & O., also enter the Dearborn Street Station by way of this plant. As the old boilers were entirely worn out a complete engineering study was made of the requirements with the result that electrically driven machinery was installed.



Interior of Compressor Room Showing Arrangement of Equipment

Equipment of the Old Plant

The equipment formerly in service at this point consisted of two 60-hp. fire-tube boilers, two Westinghouse 50-hp. high speed vertical engines, which were belt connected to two Westinghouse 115-volt generators and one 50-volt machine. There were two Norwalk 2-stage steam driven 300 cu. ft. compressors. A 6-hp. New York Safety Company steam engine was belted to a small d. c. generator for the operation of the electrical circuits on the interlocking plant during the daytime. No storage battery was included in the old equipment, it being necessary to keep one of the generators in continuous operation. Three stationary steam engineers and two firemen were employed for the operation of the plant and extra labor was required for the handling of the coal. The installation of the new equipment immediately dispensed with the service of these men.

The New Air Compressor Units

The air compressors are four cylinder single stage, Allis-Chalmers, Type A-D, 160 r.p.m. rated at 150 cu. ft. per minute. The compressor is directly connected by means of herring-bone gears to a 30-hp. three-phase, 220-volt a. c. 1160 r.p.m. motor. The compressor and motor are complete as a unit and mounted on one base. Three complete units are installed in this plant, each unit being operated a month at a time in turn. Any combination of the three units may be arranged depending on the demand for air and the settings of the governors.

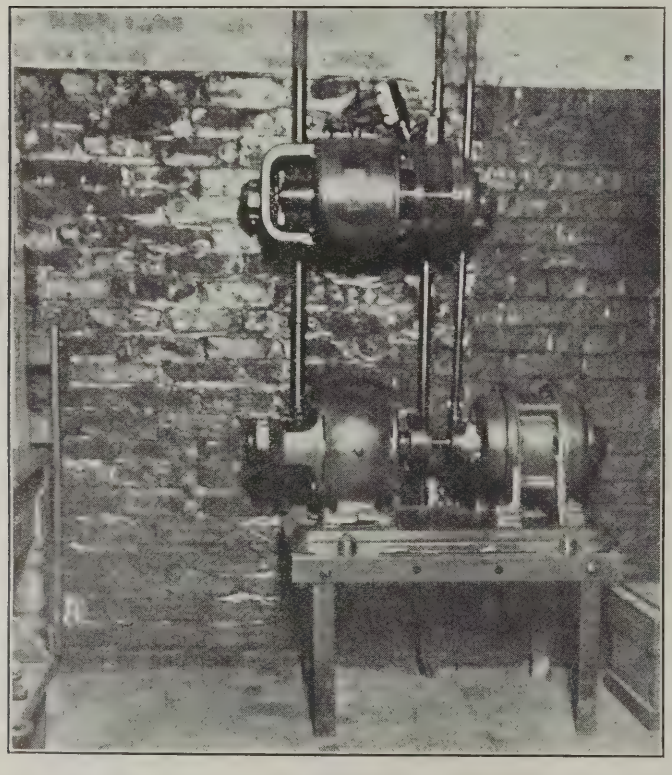
Automatic Control Apparatus

The air consumption of the interlocking plant depends considerably upon the temperature of the atmosphere and the number of leaks. At present the compressors are so arranged that they will cut in when the pressure is reduced to around 70 lb., and will stop when the pressure has been pumped up to approximately 95 lb. Under normal conditions one compressor will cut in about 12 times an hour

and will require approximately two minutes to pump the pressure from 70 lb. to 95 lb.

Above each compressor connected in the air line is a Richards type initial and pressure unloader manufactured by the Yarnall-Waring Company. This device consists of piston valve control that can be adjusted to maintain the pressure within three pounds of a certain figure. A pressure reducing valve automatically maintains a constant pressure on the pipe line and in order to prevent the motor cutting in and out more frequently the operating pressure limits are set at 70 and 95. This unloader also insures that the motor must necessarily start with no load. The valve in this apparatus controls the air which operates the gage type relay on the electric panel which controls the start and stop of the motor.

The automatic control panel for the a. c. motors are furnished by the Cutler-Hammer Mfg. Company. The function of this apparatus is to prevent a rush of current when a motor is being started. The device operates by cutting out resistance on the rotor circuits as the speed of the motor increases. Referring to the illustration on the small relay shown at the right hand bottom of the panel is the device operated by the air. This small relay starts the operation of the main relays on the panel which

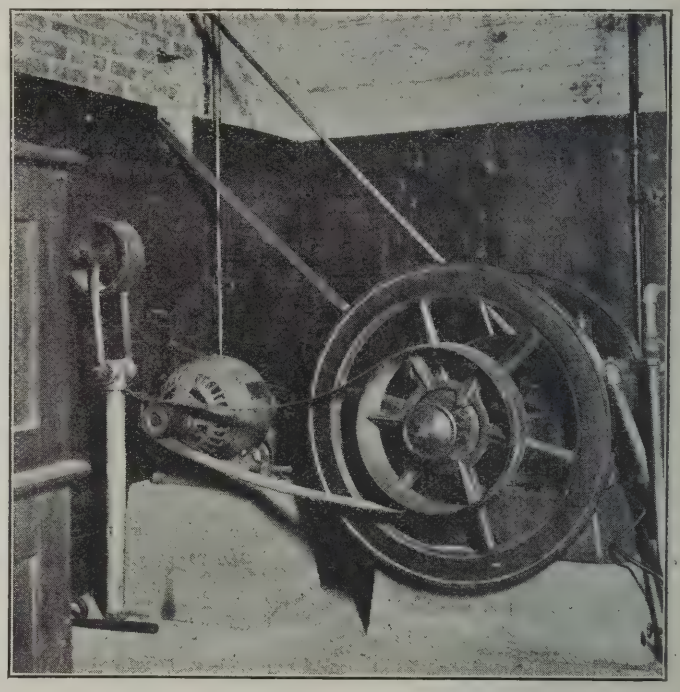


Two Motor-Generator Sets Normally Used for Storage Battery Charging

cut out the resistance in predetermined time depending upon the reduction of the current in the rotor. On account of the fact that the pressure unloader installed in the air line, functions so that the air compressor starts under no load, these motors are normally started up under no load. Therefore, the operation of the automatic switches is practically simultaneous. The small control relay has a holding feature through auxiliary contacts of the main contactors which holds it in position. With the increased pressure at 95 lb. the unloader functions and air operates the gage type control relay and cuts out the motor. Each compressor unit is equipped with a Type K-20 oil switch with low voltage release and a time limit overland release.

Switchboard Equipment

Referring to the illustration of the switchboard the equipment may be described as follows: Mounted on the left hand section are two levers for the operation of a 4-pole double throw oil switch rated at 300 amperes, 7,500 volts, which is mechanically connected and located in the transformer vault. The Commonwealth Edison



A 6-HP. Kerosene Engine and 125 Volt D. C. Generator Comprises an Emergency Supply for Signal Lights in the Event of Other Power Failure

supply is from two separate sources, each source being connected to one side of this switch.

Beneath the switch levers is mounted a Bristol recording pressure gage, which is connected to the reservoir air line. The next section contains the 220 and 110 volt service switches, the motor switches and watt hour meters. The third section carries the various battery charging and low voltage d. c. generator equipment. A fourth section carries the emergency gasoline engine generator switches.

The transformer equipment, which is located in a fireproof vault at the rear of the switchboard, consists of three 37.5 kva. 3000-220 volt transformers for the operation of the motors and a 4 kva. 3000 to 110 volt transformer for the lighting load.

The Battery Charging Equipment

Normally floating across the battery is a General Electric Type MIC-0.6 kva. motor-generator set. This machine is rated at 20 amperes, at 30 volts d. c. and 220 volts 3 phase a. c. This machine normally charges the battery at 10 amperes at 23.5 volts continuously. Held in reserve for battery charging is another motor generator set of 60 amperes capacity at 37.5 volts, d. c., operated by a direct connected 5 hp., 220 volts, 3-phase motor.

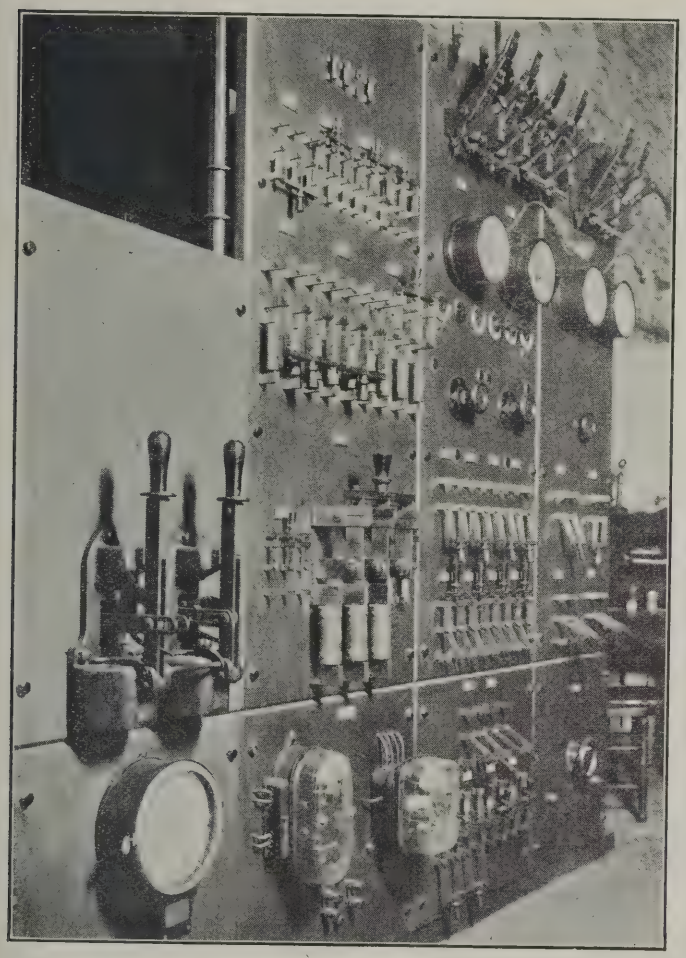
As an emergency supply for the signal lights in case

the public utility power is cut off, there is supplied a 125-volt, 28 amp. 3.5 kw. Fairbanks Morse d. c. generator. This generator is belt connected to a 6 hp. kerosene engine. The engine may also be connected to a driven bipolar d. c. generator rated at 30 amp. at 50 volts, for charging the storage batteries. This kerosene engine is further utilized by being belt connected to a line shaft operating the drill press and the lathe of the old equipment in the shop.

The storage battery equipment consists of 11 cells. Composition jars and covers are used and the entire battery equipment is enclosed in four wooden trays or boxes.

Air Supply

A 10-in. vitrified clay sewer tile was laid beneath the floor and connected to the compressor intakes. This



The Four-Panel Switchboard Showing the Type and Arrangement of Apparatus

10-in. sewer tile extends to the outside of the building and up the wall about 10 ft. and is encased in concrete. The upper end of the 10-in. tile is covered with one length of 15-in. tile with a cap over its upper end so arranged that the air must necessarily come up through the 15-in. tile and down into the 10-in. tile. This arrangement prevents the entrance of any dirt or cinders and provides an unrestricted passage for the air.

From the compressor the air passes to an after cooler rated at 48 sq. ft. of cooling surface located in the corner of the building. This cooler contains 16 tubes through which the water is circulated. This device cleans practically all the water and oil out of the air. The air passes on through a system of ¾-in. pipes which further cools the air, and on down through a 36 in. x 96 in. reservoir and to the reducing valve. This reducing valve automatically holds the pressure at 70 lb. which is carried on the main line to the various functions of the interlocking plant.

Water Cooling System

In order to be independent of a shut down of the city water supply a separate cooling system is provided for the circulating water used for the after cooler, the compressors, and the gasoline engine. One of the old boilers is used as a cooling tank. This boiler has 48 4-in. flues and is 60 in. in diameter and 17 ft. high. This boiler is placed on end and held in position by means of rails set in concrete. Air circulating around this boiler and through the flues proved to be more than sufficient for the cooling of all the water required. It has been found that after a short time all of the sediment and chemicals are deposited from the water and further cleaning is not necessary as would be the case were city water used directly.

The entire plant was built with the idea of insuring continuity of service. Providing both supplies of electric power are cut off, air can be brought to this plant by a separate air line from another interlocking. Providing that power is always available on one of the two sources it is fair to assume that one or more of the compressors will always be ready for service. Two motor generator sets are provided for charging storage battery and in case these are both out of order the battery may be charged by the gasoline engine generator.

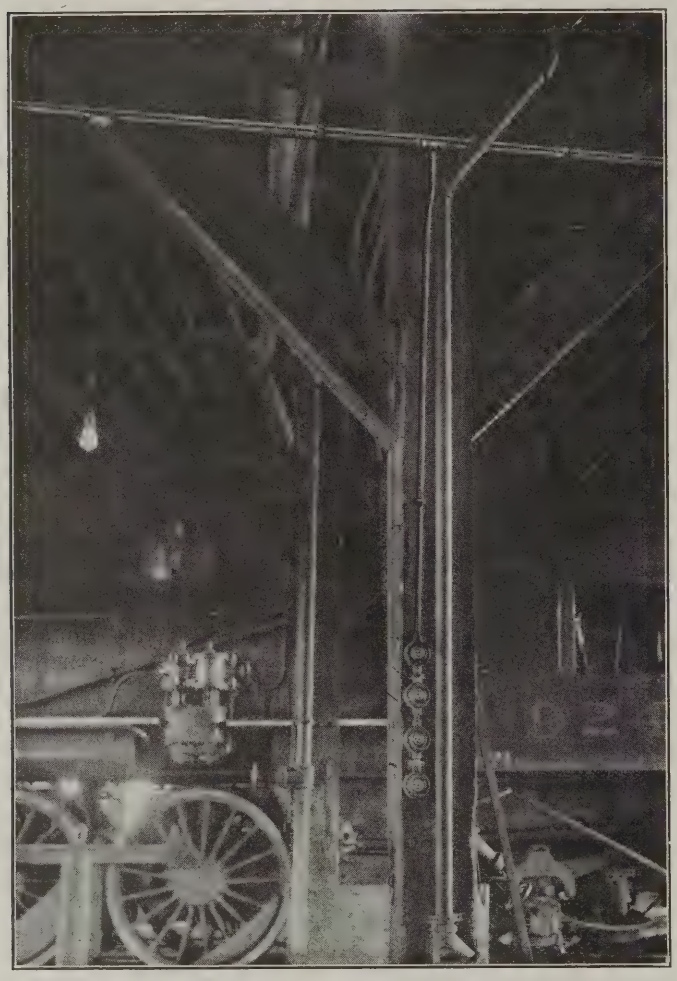
The cost of current for the operation of this plant for one day is approximately $8, which is about one-half of the cost of the coal alone for the same day under the old scheme of operation. It was estimated that the saving produced by the installation of this new machinery will easily pay for the equipment within a period of three years

The entire installation of this new equipment including the installation and testing of all machinery, wiring and air pipes was handled by the forces of the Chicago & Western Indiana.

An Old B. & M. Locomotive with Polygonal Faced Driving Wheels Designed to Increase Adhesion (now Converted into Standard Eight-Wheel Passenger Locomotive)

Enginehouse Lighting on the Rock Island

All conduit below the gas line and a row of overhead lights between stalls are the features which characterize enginehouse lighting on the Rock Island. The standard method of wiring used consists of running the



Section of Wiring System Used, Showing Supporting Messenger, One Lighting Unit and Set of Extension Outlets

conductor wires in rigid metal conduit which is suspended from cables stretched below the gas line. The supporting cable or messenger consists of a 3/8-in., 7-strand galvanized steel cable which is stretched from the inner to the outer walls between each stall at a height of from 12 to 14 ft. from the floor. The conduit is clamped to the messenger cable at intervals by an iron pipe strap secured with a 3/16-in. stove bolt. The conduit which is suspended directly from the messenger cable is 3/4-in., and 1/2-in. conduit is used between this and the extension outlets mounted on the supporting columns.

In the conduit No. 12 B. & S., solid copper single strand, 3/64-in. rubber insulated wire is used, and twisted pair No. 14 B. & S., 26-strand brewery cord with single braid, and 2/64-in. rubber insulation is used for the drops. The drops are brought out of the overhead conduit through "J. & K." condulets. The connections are made in the condulet, after which the conduit is filled with Chatterton compound. The compound makes the conduit practically gas tight. A spring type weatherproof lamp socket is used at the end of each drop. For the average roundhouse, four 60-watt lamps are used for each stall.

A set of four Hubbell, 20-ampere extension receptacles are mounted on the middle post of every other stall. The extension circuits are energized at all times.

The lights and extension outlets in an enginehouse section, usually consisting of 10 stalls, are fed from one distribution box which contains the cutouts and switches. Not more than 12 lamp outlets are allowed per circuit and the wiring is so arranged that the lighting of a section is controlled by two double pole knife switches. This method of enginehouse wiring and lighting has been in use on the system for several years and the estimated life of an installation is 10 years.

After stainless steel had been successfully manufactured, it was found that stainless iron could be produced by much the same process, with the exception that a smaller quantity of carbon-free ferrochrome was required. Stainless iron has been already largely used in the Sheffield cutlery trade and in the fittings of motor cars. Another important development in contemplation is the use of stainless iron for the furnishing of railway carriages, engines, and rolling stock generally. It is also proposed that it should replace brass for door handles, brackets, and many other fittings. As might be expected, the manufacture of stainless iron and steel is already being rapidly taken up by our American manufacturers.

Photo from Ewing Galloway

Railroad Yards at Toledo, Ohio

Metallic Arc Welding of Manganese Steel*

Peculiar Metallurgical Characteristics Which Must Be Taken Into Consideration to Secure Best Results

AS actually made, manganese steel contains about 12 per cent of manganese and 1.25 per cent of carbon. The presence of 1.50 per cent of manganese makes steel relatively brittle and a further addition at first increases this brittleness, so that steel containing between 4 and 5.5 per cent can be pulverized under the hammer. A still further increase, however, gives it great ductility, accompanied by great "tough hardness"—a combination of properties which was not possessed by any other known substance when this remarkable alloy, known as Hadfield's manganese steel, was discovered. Its "tough hardness," to which it owes its value, is profoundly affected by the rate of cooling. Sudden cooling makes the metal extremely hard and ductile; slow cooling makes it brittle. Its behavior in this respect is thus opposite to that of carbon steel. High manganese steel is used extensively for objects which require both hardness and ductility. Its remarkable toughness, resistance to shock and abrasive action make it ideal for rock-crushing machinery, railway crossings, mine car wheels, tractor parts, etc. As no process softens manganese steel it must be cut to shape with emery wheels instead of the usual steel cutting tools. It may also be cut with the oxy-acetylene torch.

The extreme brittleness noticeable with steel containing manganese between 4 per cent and 5.5 per cent disappears in steel exceeding about 7.5 per cent manganese, as will later be shown by the physical qualities with respect to the manganese and carbon content.

A non-magnetic characteristic is noticeable around 8 per cent manganese, and at 12 per cent manganese is practically non-magnetic. As it is extremely difficult to cold work manganese steel, manganese wire is drawn only by very special methods.

Manganese steel is a very poor conductor of heat, it having a relative conductivity of only 2.31 (copper 100 per cent), or 75 michrons per cu. centimeter at 15 deg. C. This is about one-seventh the conductivity of iron wire.

The following table shows the effect of varying quantities of manganese and carbon on the physical quality of the product, and will serve as a guide as to its limitations in this respect. The tests were made on forged manganese treated as indicated.

TABLE OF TESTS†

Test No.	Carbon	Mang.	Treatment	Tensile breaking tons per sq. in.	Elongation percent 8 ins.	Appearance of Fracture
1	.52	6.95	Cooled in air, from white heat.	21.07	1.50	Coarse and granular.
2	.52	6.95	Cooled in oil from white heat.	18.76	2.34	Very coarse and bright.
3	.52	6.95	Cooled in water from white heat.	23.25	1.56	Coarse and granular.
4	.50	7.90	Heated as above cooled in air	28.35	7.81	Coarse and granular.
5	.50	7.90	Cooled in oil.	29.61	7.03	Coarse and granular.
6	.61	9.37	Cooled in oil.	38.20	14.84	Coarse and granular.
7	.61	9.37	Cooled in water.	38.87	14.84	Finer.
8	.95	10.11	Cooled in air.	39.29	14.06	Coarse and granular.
9	.95	10.11	Cooled in oil.	41.00	19.53	Coarse and granular.
10	.72	10.83	Cooled in water.	47.53 to 53.14	22.0 to 28.9	Coarse and granular.
11	.85	12.29	Cooled in water.	55.12 to 64.84	35.9 to 45.31	Coarse and granular.
12	.85	12.29	Cooled in air.	39.34	3.5	Fibrous.
13	1.10	12.60	Cooled in water	53.91	27.34	Fibrous.
14	.85	13.75	Cooled in water.	60.60	47.6	Fibrous.
15	.85	14.01	Cooled in water.	67.13	44.44	Fibrous.
16	1.55	14.16	Cooled in water.	44.84	14.06	Carbon too high.
17	1.1	14.48	Cooled in water.	63.36	37.5	Carbon too high.
18	1.54	18.4	Cooled in water.	53.24	10.1	Carbon too high.

*Paper presented before the Chicago section of the American Welding Society, by H. R. Pennington, supervisor of electrical equipment and welding, Chicago, Rock Island & Pacific Railroad.

†Institute of Civil Engineers, Minutes of Proceedings, 1887-1888, Vol. XCIII.

These tests, although made several years ago in England by Sir Robert Hadfield, show a number of interesting results, especially from a welding point of view. For example, the beneficial effect of sudden cooling in cold water is clearly shown as indicated by tests Nos. 9, 10, 11 and 12.

Tests Nos. 4, 5 and 6 show approximately the minimum amount of manganese and carbon above the amounts present in the usual manganese steel from which any beneficial effect is noticeable. The quality increases with increase of carbon and manganese up to about 1.00 per cent carbon and 12 to 13 per cent manganese, as shown by tests Nos. 11, 13, 14 and 15. Test No. 16 shows the bad effect of an excess of carbon content.

The beneficial effect of sudden cooling, as well as the good physical qualities which may be obtained within a fairly wide range of carbon and manganese between the maximum and minimum limits is reassuring, especially as regards sudden cooling, as this feature is greatly facilitated by arc welding, which permits cooling as frequently as necessary with but little interference with the welding operation. By use of a proper protective coating on the electrode, sufficient carbon and manganese will be retained in the weld or "arc deposited metal" to insure being within the desired limits, as will later be shown.

Chemically the usual cast manganese steel has about the following composition:

	Percent
Carbon	1.25
Silicon	0.30
Manganese	12.30
Sulphur, less than	0.02
Phosphorus	0.08

The average of a number of physical tests of cast manganese steel of the above analysis shows the following results:

Tensile Lbs. Per Sq. In.	Elastic Limit— Lbs. Per Sq. In.	Elongation Per Cent in 2 In.	Reduction of Area, Per Cent
108,460	53,396	33.71	38.56

By the Brinell test, manganese steel toughened or untoughened, shows the moderate average hardness number of about 200. The extreme outer surface of the treated steel shows a slightly lower number—that at a depth of about ⅛ in., from which point the number remains constant. The lowering of the hardness number at the surface is due to the oxidation of the carbon during the heat treatment.

The chemical composition and physical properties of the manganese rods and wire used for welding are as follows:

Chemical—	
Manganese	11 to 14%
Carbon	1.00 to 1.30%
Silicon	0.10 to 0.20%
Phosphorus	0.05 to 0.09%
Sulphur	0.01 to 0.03%

Test: Rolled and Forged—

Ultimate tensile strength	140,00 to 160,000 lbs.
Elastic limit	60,000 to 75,000 lbs.
Elongation	35% to 50%
Shearing strength	100,000 to 110,000 lbs.

Cold Drawn Wire—

Test on ⅜-in. Drawn Manganese Steel Wire.
Wire not heat treated after last draw.

Ultimate tensile strength per sq. inch	193,000 lbs.
Elastic limit per sq. inch	135,000 lbs. (70%)
Elongation	20% in 8-in.
Bonds	4
Torsions	18 to 8-in.

The beneficial effect of the cold working incidental to drawing to wire form is very marked, particularly the tensile strength and elastic limit. In the same way it is believed that the metal added by welding to a crossing or frog is improved in the early period of service, due to the constant rolling effect of the passing traffic.

The following test shows the average percentage less of carbon and manganese for a Wanamaker Coated Electrode No. 9 when fused by the metallic arc process and deposited on a carbon steel rail.

ANALYSIS OF WIRE BEFORE WELDING

Carbon	0.99%
Sulphur	0.022%
Phosphorus	0.043%
Manganese	10.51%

ANALYSIS OF DEPOSIT ON RAIL MADE FROM ABOVE WIRE

Carbon	0.71%
Sulphur	0.018%
Phosphorus	0.061%
Manganese	10.19%

The following tests were made to show the effect of polarity and the influence of the bare metal on the composition of the deposit, the deposit being made on a piece of mild steel ⅝-in. boiler plate:

	Wire Electrode	Electrode Neg. Deposit	Electrode Pos. Deposit
Carbon	.85	.63	.83
Manganese	11.2	8.11	8.11
Phosphorus	....	0.034	0.032
Sulphur	....	0.010	0.012
Silicon	....	....	....

A greater loss of manganese is shown by the deposit on the mild steel plate over that obtained on a carbon steel rail. Concerning the effect of polarity, a greater loss of carbon is shown when using electrode negative than that obtained with the electrode positive. The usual practice is to use an electrode-positive polarity for manganese electrode material.

In the cast state, manganese steel is composed principally of austenite and free cementite, austenite being a solution of iron, manganese, and the carbide of iron and manganese, while free cementite is composed of the carbides of iron and manganese which remain undivided. Free cementite is hard and brittle, therefore manganese steel is also brittle in the untreated cast condition. When, however, it is water toughened, the free cementite is dissolved and the cast manganese becomes austenite, which is ductile. In the process of toughening it is quenched from 1,800 deg. F. in cold water.

The proper temperature from which arc deposited manganese steel should be quenched is a point which has been questioned by some investigators. Some tests have shown a falling off in tensile properties and elongation on quenching from a temperature in excess of 1,800 deg. F. The following tests made on ⅜-in. diameter round bars heated to the temperature given for one hour, and quenched in water, tends to confirm this belief. The duration of heating, however, has almost as important an effect as the temperature itself.

**Heated 1 Hr. at	Elongation Per Cent	Breaking Strain Lbs. Per Sq. In.
1800° F.	56.5	133,400
2100° F.	35.7	93,200

**American Institute of Mining Engineers, Vol. L., 1914.

Another test made on the same material by heating test pieces to the temperature shown for only five minutes, shows a considerable less lowering of the tensile and elongation properties, as indicated below.

Heated Five Minutes at	Elongation Per Cent	Breaking Strain Lbs. Per Sq. In.
1800° F.	56.4	142,450
2066° F	34.4	124,780

In this case the higher temperature did not affect the elongation and tensile strength nearly as much as when heated at the higher temperature for a period of one hour. The short time at the maximum temperature apparently did not give the steel quite enough time to come fully to equilibrium. In consequence, the structure of the test bars was not greatly altered from that which existed prior to the heat treatment. All test bars when quenched from the heat of rolling showed the following properties, without further heat treatment:

Elongation Per Cent	Breaking Strain Lbs. Per Sq. In.
53.3	157,250

In the process of welding, the time period for the heating and cooling cycle is a matter of seconds due to intermittent cooling of parent metal with cold water. For this reason the physical properties of the arc fused metal although cooled from the melting point 2,507 deg. F. to 2,462 deg. F. would not be injured in any way comparable to that where the metal has been heated for a comparatively long period.

The same lowering of tensile strength and elongation is shown when manganese steel is drawn or quenched from some lower temperature points than the established practice 1,800 deg. F. and when the usual method of heating is employed. In the case of arc welding, however, the metal adjacent to the arc deposited metal cooled from these lower temperatures is not thought to be injured for the same reason as in the case of cooling from extremely high temperatures, i. e., the rapid heating and cooling incidental to arc welding would not give ample time for normal structural changes to occur.

Metallic Arc Welding of Manganese Steel

So far as known, the commercial welding of manganese steel up to the present time was accomplished only by the metallic arc process with coated manganese electrode material and by water toughening the added metal, the metallic arc form of autogenous welding being particularly adapted to the welding of metal of this character, since it is about the only form of autogenous welding which permits, without difficulty, the water toughening treatment of the added metal.

The normal water toughening treatment amounts to raising the temperature of the metal until the desired structure is produced, and fixing it at that point by an increase of the normal cooling rate. Likewise, in the case of welding manganese, the metal heated to a high temperature by the welding operation is suddenly cooled from a temperature as near equal to that for the desired structure as is possible.

Electrode Material

The use of a protective coating of the proper character on the electrode material is necessary to prevent vaporiza-

tion of the manganese and carbon constituents due to combustion, supported by the oxygen of the atmosphere. The function of the coating is to envelop the metal in fusion with a thin slag film, confine the arc gases and exclude to a great extent the atmospheric gases.

The coated manganese steel electrode material is furnished in the following standard sizes:

Diameter	Length
1/8-inch drawn	14 inches
5/32-inch drawn	14 inches
3/16-inch rolled	14 inches
1/4-inch rolled	14 inches

The size most generally used for track work is 3-16 in. and 1/4-in. The 3-16-in. size seems better adapted for general work, especially where 200 ampere welding units are used.

The approximate arc current and voltage values for manganese electrode material are as follows:

Diameter Electrode	Approx. Current Arc	Approx. Voltage Arc
1/8-inch	100-120	20-25
5/32-inch	150-170	22-28
3/16-inch	175-200	25-30
1/4-inch	225-275	25-30

The arc length should be maintained as short as consistent for a uniform flow of metal about 3-16 in. If with this arc length the metal does not flow smoothly, it is likely that the arc current value is too low.

Polarity

In practice it is found that an electrode-positive polarity gives a better welding characteristic and that the loss of carbon and manganese is less. For this reason where direct current is used, the electrode is made the positive and the work piece the negative.

Arc Manipulation

When welding with manganese steel on either manganese or high carbon steel, it is found advisable to form a rather wide deposit by a slight oscillation of the electrode, to give a deposit approximately double the width of that obtained by drawing the electrode along a straight line. By this manipulation the deposited metal is kept in a molten condition for a slightly longer period, allowing time for the escape of any gas which may be included in the deposit, and thus preventing the formation of blow holes.

Water Toughening

To prevent the formation of a brittle structure, the work piece including the weld area is kept cool by quenching with cold water *immediately* after each electrode is used and more often on light sections where the part tends to become too hot, or at any time the welding is interrupted. The result to be accomplished is to keep the work piece cool enough to exercise constantly a quenching action on the deposited metal. Unless the cooling by water is frequent, the rate of cooling will be variable with a corresponding difference in physical character of the added metal.

In track work the cooling is accomplished by directing a small stream of water directly on the previously deposited metal until the heat retained in the part will just dry or vaporize the water. Before the welding is again continued, the surface where the arc is to be established must be dry, otherwise difficulty will be experienced in establishing the arc. It is desirable to wipe the surface dry with a piece of waste when necessary before starting the arc.

Welding Procedure

When building up track parts, such as frogs and crossings, it is advisable to apply each deposit diagonally to the direction of the traffic, and terminate the weld on a bias, the point of the bias being on the flange side of rail, as shown by the accompanying sketch. This procedure is thought to be the best practice in order to minimize the effect of construction and possible structural disturbance on the parent metal from the heat of the welding operation.

To avoid roughness or overrunning of the added metal at the flange side of the rail and on both sides of points, a piece of fire brick or carbon block should be set in the flange groove so as to project up and form a wall for the added metal to flow against. The use of fire brick or carbon blocks for making forms at the extreme points and edges will greatly facilitate the welding and result in better and more uniform work.

Where welding is done out in the open, a small shield 8 or 10 in. high should be set up to shield the arc from the eyes of observers and from air drafts, especially on windy days. Unless the arc is protected from air drafts, welding will be very difficult and an unnecessary loss of carbon and manganese will result.

Finishing

If desired, the weld may be finished by grinding to allow a smooth approach for the wheel and prevent impact at the junction of the weld. However, if pains are taken by the operator to make as smooth a weld as possible, grinding is not considered absolutely necessary. The natural flowing characteristic of manganese steel will in a short time result in the weld becoming quite smooth. The operator should not only endeavor to make a smooth weld but should also use care to see that the top of the weld is level with other parts of the track work, being particular to avoid sharp humps or low spots.

The records of a number of applications which have been made in both steam railroad and street railway tracks, seems to have little doubt as to the commercial success of arc welding manganese steel. On a service cost basis, the service already obtained from welded crossings is such as to insure the permanency of the process.

Increasing Welding Speed

One of the most important questions facing the advocates of fusing welding is that of finding methods of increasing the speed of arc welding. The possibilities in this direction will be pointed out in this paper, and it is hoped that this introduction of the subject will result in some constructive discussion.

Welding speed on a given section is fundamentally dependent upon the rate of metal deposition and the amount of metal required to effect the jointure.

The first factor—rate of metal deposition—varies with the energy required to liquefy the electrode material, are stability, current density, etc. The amount of metal which must be applied obviously depends upon the type of joint and opening necessary to effect fusion between the edges or members to be joined.

The size electrode and arc current value that can be used, seem to be limited only by the thermal capacity of the base metal or joint. That is, the heat or arc current and electrode diameter can be increased until the molten metal of the weld area becomes difficult to control, or

until the effects of expansion and contraction becomes an obstacle, and both these are governed largely by the thermal capacity of the joint.

One of the principal obstacles encountered in the past on attempting to use large diameter electrodes, was the poor welding qualities of such materials. With ordinary large diameter bare electrodes, a violent sputting arc throwing out metal in all directions is a common occurrence at arc current values exceeding 200 amperes, and at 300 amperes the disturbances render the arc control very difficult and extremely uncomfortable.

No doubt one reason for this is the fact that the beneficial effect to the welding characteristic incident to drawing of electrodes in wire form are not present to the same extent in large diameter electrodes or what would commonly be classed as rods. These disturbances and poor welding characteristics of large electrodes generally resulted in inadequate penetration and un-uniform fusion.

If the electrodes are coated, a quite stable arc will be secured, permitting welding with metallic arc up to 500 amperes, with adequate penetration, uniform fusion and with a considerably lower electrode current density than that required for bare wire.

As a working basis for comparison, the rate of deposition for the usual size bare electrode and that of ¼-in. coated, both of mild steel grade on ½-in. plate wire, were determined with the following results:

Elec. Dia.	Arc Amps.	Lbs. Elec. Consumed Per Hour	Ft. Per Hr. Single Fillet Lap Weld	Lbs. of Elec. Per Ft. of Fillet	Elec. Current Density
5/32 in. bare	150	2.3	6.8	0.33	7850
¼ in. bare	300	7.7	10.4	0.74	6220
¼ in. coated	300	8.09	18.6	0.43	6220

It will be noted that the increased speed of ¼-in. bare over 5/32-in. bare is not in proportion to the increased arc current. The increased pounds of electrode material per foot of fillet is due to the excessive amount of metal loss in passing through the arc.

The lower speed and rate of deposition of the ¼-in. bare as compared to ¼-in. coated is due to the difficulty of controlling a high current arc when using bare electrodes. Despite the greater amount of metal deposited, high current welding resulted in over a 100 per cent increase speed of welding of a single fillet lap joint.

These figures were obtained under ideal conditions and could not be equaled in commercial practice, as further tests have proven. However, the relative speed between small diameter bare electrodes and large ¼-in. coated electrodes with high arc current will remain practically the same. An additional factor to consider in using large electrodes is the fact that the time required to consume a large electrode is greater than that for a small one, and therefore the percentage of welding time is actually increased. This load cycle should be given consideration when determining the capacity and basis of ratings of welding units for large electrode welding.

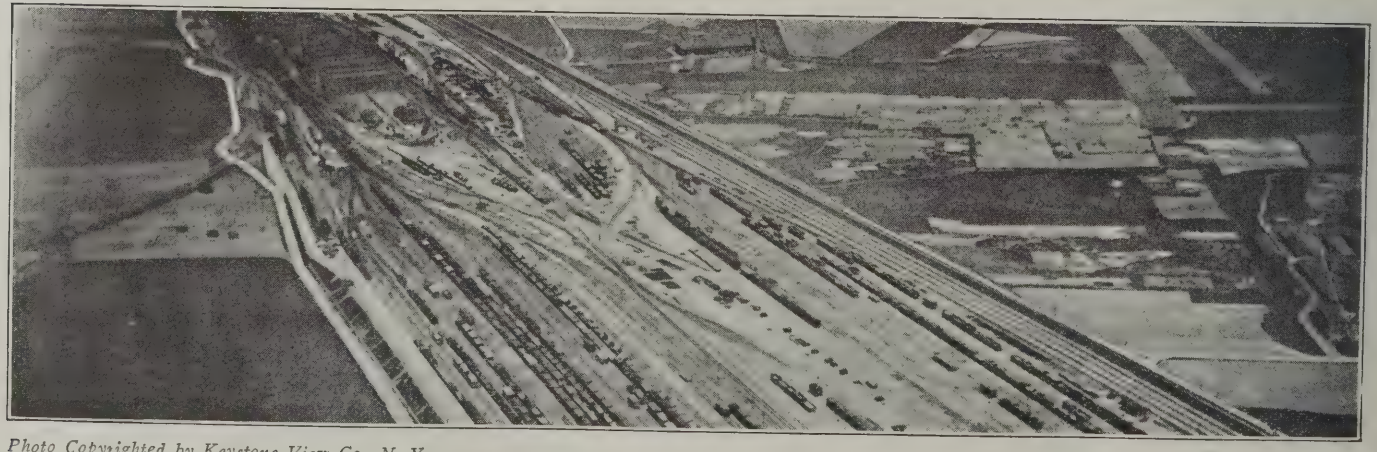
Experiments with high currents and large electrodes with exceptional penetration qualities, indicate that the speed of butt welding can be increased by 100 per cent over present practice, especially since by using deep penetration electrodes the amount of scarfing necessary would be greatly reduced, if not eliminated, on plate thicknesses up to ⅜ in. A reduction in the amount of scarfing is also desirable where high arc currents are used, in order to increase the thermal capacity of the joint.

The lap joint offers greater advantages, however, for large electrode welding than the butt joint, as the lap joint possesses inherently the requisite high thermal capacity and therefore permits a high energy concentration with an attendant high rate of fusion and deposition. In addition, lap joints with double fillet will permit of 100 per cent weld strength being secured without difficulty.

A recent check on pounds of metal consumed per hour, using ¼-in. mild steel coated electrodes with 240 amp. arc current, showed the rate of deposition to be 6 lb. per hour. These figures were obtained from actual shop practice on locomotive frame welding and include time for considerable cleaning necessitated by applying successive layers in a vertical position.

From the foregoing it is clear that the limit of speed and rate of metal deposition has by no means been attained in present-day practice, but in order to permit the use of higher arc currents, the electrical resistance of the electrodes must be decreased by an increase of electrode area. Otherwise, difficulty of arc control will be experienced, due to overheating of electrode.

Attention has been drawn to the possibilities in this direction in order that those contemplating the adoption or extension of arc welding may give consideration to high arc current welding, which from present indications will be increased to at least 300 amperes for a great majority of the work now done, with arc current values not exceeding 200 amperes.



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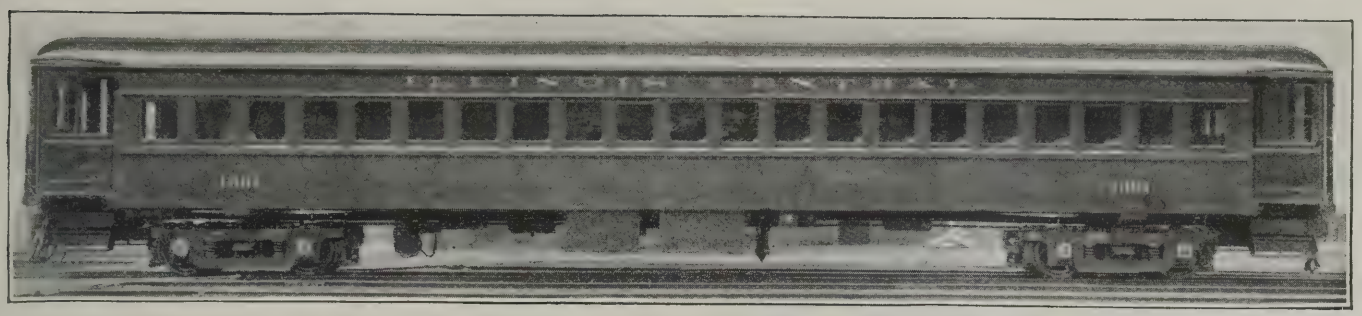
An Aerial View of the Yards at Cologne, Built During the War



Electric Features of New I. C. Coaches

Provision Made for Future Electrical Propulsion; Door Operating Mechanism and Starting Signals Unique Features

THE Illinois Central has recently placed in service in its Chicago district 20 new steel suburban coaches. These cars will be used in steam service until the terminal is electrified, but they are so designed that they may be equipped with motors and multiple unit control apparatus. The hand brakes are placed on the left side of the vestibule platform leaving the right hand space available for the installation of controllers, air brake equipment, gages, etc. When the electrification is completed, the steam heating apparatus will be removed from these cars and electric heaters substituted. Electricity for lighting will then be obtained from the power source.

As a means of providing electric lighting, until the electrical propulsion is begun, a complete axle lighting system with batteries and control apparatus has been installed. The control panel, and ampere hour meter are mounted in separate steel cabinets under each car. These cabinets, like the battery compartments, may be removed from the car when changes are made, without disturbing the other equipment. There is no train line or provision made for the inter-connection of the lighting equipment between the adjacent cars.

The generator is a 2 kw., 50 ampere, 32 volt machine of the body hung type. As these cars are used exclusively for suburban service it was considered necessary that the generators be so adjusted to give full load at the low speed of 16 mi. per hour. During the time these cars have been in service it has been shown that this low adjustment is not required in summer as the battery has been receiving more charge than is necessary. The axle pulley has a 10 in. face and a 2 in. flaring flange.

The regulator panel is mounted in a separate steel cabinet beneath the car body. The cabinet has two hinged doors that are padlocked, keys for which are furnished to employees of the electrical department only.

An ampere-hour meter, rated at 60 amperes, 500 ampere hours is mounted in a separate steel cabinet beneath the car. This cabinet is provided with a glass front.

Twenty-four cells of Edison type A-6-H battery, assembled in six trays of four cells each, constitute the battery equipment for each car. A charging receptacle is mounted on each side of the car. A cast iron fuse box, provided with a hinged cover and winged nut hasp, is mounted on each end of the battery compartment.

All wiring is placed in conduit and Pullman standard castiron junction boxes are used throughout. All of the wiring is according to the standard sizes as required by the American Railway Association specifications.

Fourteen, 20-watt, 28 to 32-volts lamps are provided for each side of the car and one lamp is mounted on each side of both vestibules. The fixtures mounted on the edge of the monitor deck are provided with the Soudan style of moulded glass reflectors. The lamps are arranged on four separate circuits which are controlled by snap switches mounted in a small cabinet, which is recessed in the end of the car and which is accessible from the vestibule.

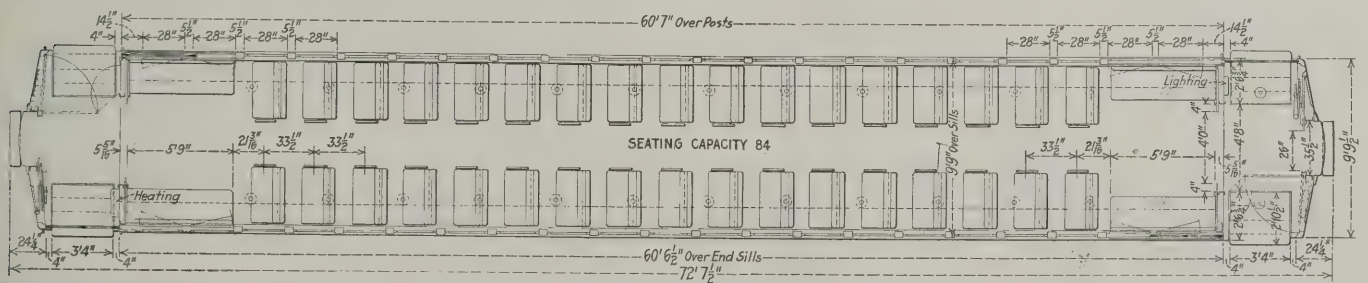


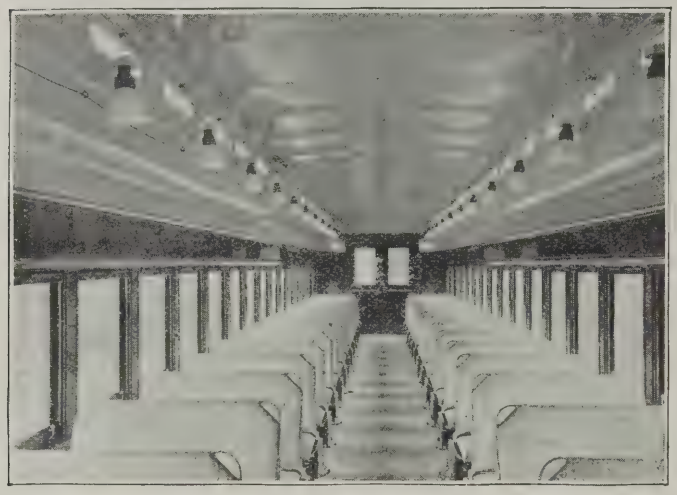
Diagram Showing Principal Dimensions

The Door Operating Mechanism

The vestibule side doors are operated by air engines, electrically controlled. A separate ¾-inch air line runs through the train and is connected into the main air reservoir on the locomotive. No signal air line is used in the train. There is a reservoir on each end of every

car which stores up enough air to operate the doors ten or twelve times after the locomotive is cut off.

One air engine is provided for the operation of each of the four doors on the car. This mechanism is located under the end seat. The admission of air to the operating cylinder is controlled by valves operated by electric solenoids which are wound for 30 volts operation. Current for these valves is taken directly from the car lighting battery through a pair of fuses which are mounted in



Interior of Coach Showing Arrangement of Lighting Fixtures

the lighting switch cabinet in vestibule at the end of the car. The valves are directly controlled by double lever switches which are mounted in castiron boxes at each side of the doorway leading to the adjacent car. These switches are so arranged that a trainman may operate all of the doors from either end of the car or all of the doors of the two adjacent cars, thus in a four car train there would be a trainman between the first and second cars and another between the third and fourth

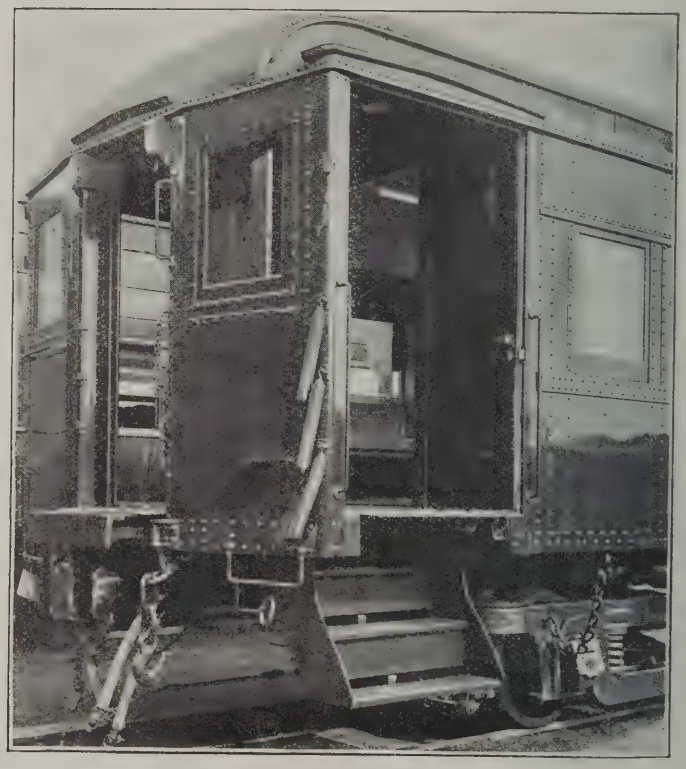
The Regulating Panel is Located Near the Storage Battery

cars. These switches may be locked in the off or neutral position by a thumb lock.

In the event of an electrical failure the air valves may be operated by hand without removing the seat. If the air supply fails the doors may be operated by a hand crank which may be attached to the extension of the engine shaft. In case a door is closed on an object which prevents further movement it automatically opens to 36 in. opening and closes again. This movement being automatically kept up indefinitely until the obstruction is removed. This action is accomplished by electric contacts mounted on the edge of the door protected by a flexible rubber casing. As a further safety feature there is a collapsable arm on the engine shaft so that the door may be opened about 6 in. from its closed position.

Starting Signal

As a starting signal there are two 34-volt green lights in parallel mounted in the cab of the locomotive. These lights are energized by a series circuit through the train, taking power from the headlight generator on the locomotive. Electrical connectors are used between the cars and the receptacles on the cars have a self-closing switch mounted on air valve so that the circuit is closed on the rear of the last car when air cock is closed. The series circuit is carried through contacts, on each side vestibule door. When all the doors are closed the green lights in



End Construction of the New Coaches

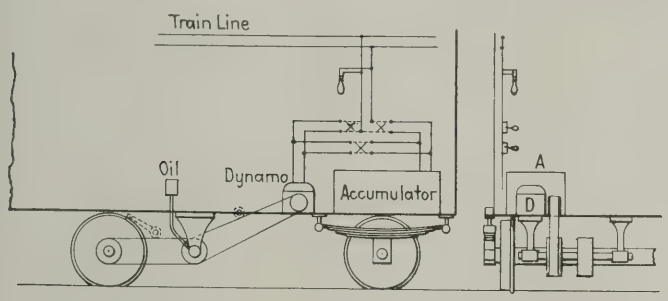
the locomotive are lighted. Two lamps are used in parallel to prevent a failure should one lamp burn out.

The overall length of these cars is 72 ft. and 2 in. The interior finish of the cars is white from the side plate to the side plate overhead, including the fixtures. The sides are of mahogany color as well as the seat and ends. The seats are finished in cane. Cross seats are the walk-over type. No foot rests or arms are provided. The four longitudinal end seats have a capacity of four each. The total seating capacity of the car is 84 persons. The seating arrangement was particularly designed with a view of having ample clearance between the seats and ample height at the back of the seats for the use of the passengers. The width of the aisle at the seat end is about 31 in. and 36 in. at the edge of the seat back which provides ample room for two persons to pass in opposite directions in the aisle.

Some Early Developments in Train Lighting

PASSENGER trains operating between London, England, and Brighton, a distance of some 52 miles, were first equipped with the electric light apparatus in 1881. According to A. A. Panter, carriage and wagon superintendent of the London, Brighton & South Coast Railway, this is believed to be the first attempt to light a train by electricity.

The first installation consisted of accumulators as the only source of energy, the battery being placed on charge at night during the time the train was on the siding.



Arrangement of Driving Pulleys and Electrical Equipment

This was not satisfactory, as the batteries seldom received the necessary charge. About 1883 an apparatus was designed by the late E. J. Houghton whereby the accumulators were charged by a dynamo placed in the guard's van or baggage car, and driven by a belt from the car axle. Belts were of single-ply 4-in. leather.

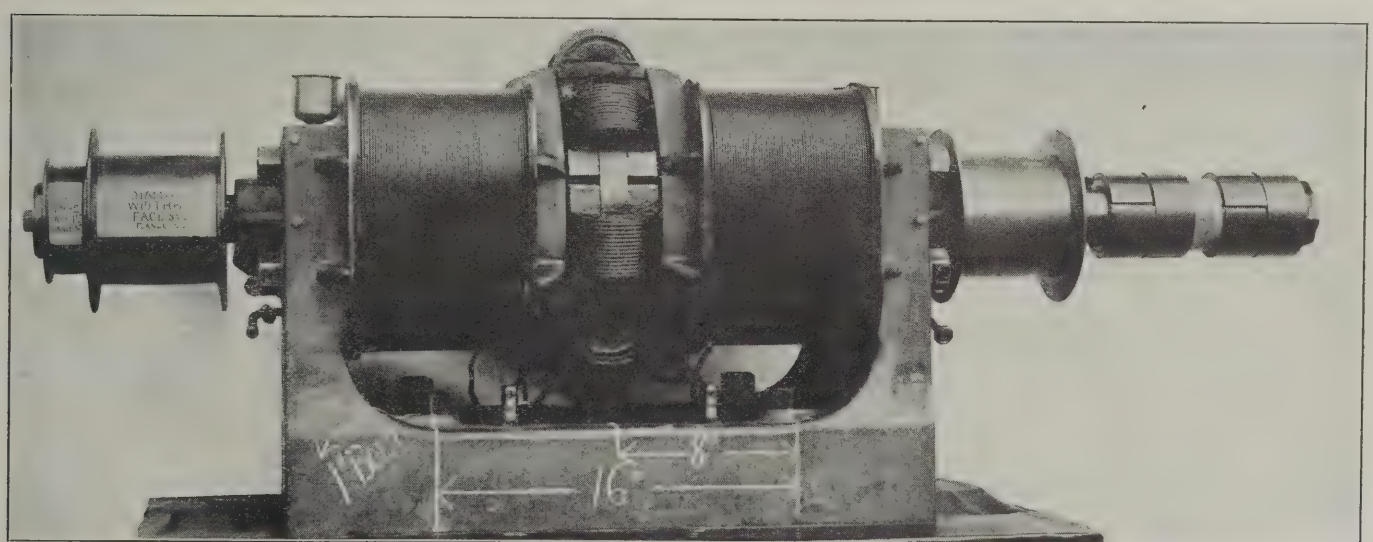
For the benefit of the reader not acquainted with cars used on English railways, it may be said that these cars were equipped with three pairs of wheels, placed equally under the car, the bearings being so arranged as to permit a side motion to allow the cars to round the curves safely.

A pulley approximately 12 in. in diameter with 4 in. face was mounted on the center axle. Attached to the underframe of the car was a shaft supported by inverted hangers. On this shaft were two pulleys, one of which was driven from the pulley on the axle, the other being used to drive the dynamo located in the car diagonally above the shaft. Lubrication of hanger boxes was accomplished by copper pipes leading through the floor of car to oil cups with wick oilers. All bearings were of brass, as babbitt metal bearings were then unknown. The dynamo was manufactured by the Brush Electrical Engineering Company and the illustration gives a general idea of the construction of these machines.

As the dynamo was driven at all times when the car was in motion, a double-throw, double-pole switch was connected into the circuit in such a way that the lights were switched from the generator to the battery when the train was stopped or vice-versa when the train was under way. A two-wire circuit was run through the train line and apparently no adjustments were made for the regulation of the voltage between the lamps in the different cars. The variation of voltage was naturally considerable. Plug connectors constructed on the same principles as those of today were used to connect the train line between the cars.

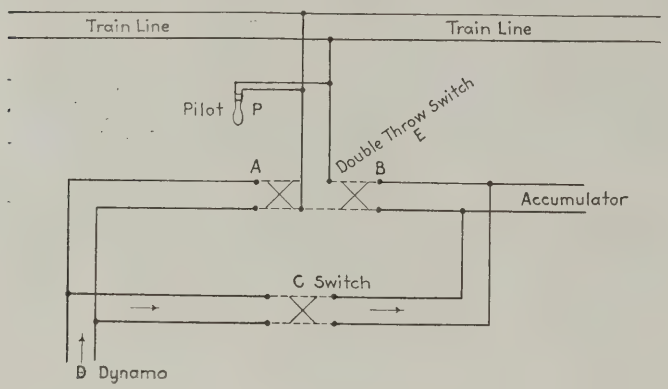
The operation of this system of lighting proved to be satisfactory, although at the beginning there was some trouble from the burning out of armature and fields from excessive speed, as well as many burned out lamps. The platinum filament made this an expensive proposition. This was overcome by changing the relative size of the pulleys. Eventually 400 coaches and special cars were equipped on this one railway. There are today still several coaches and private cars, including the royal train, fitted with the E. J. Houghton apparatus running on this railway, but with the addition of modern regulation apparatus. The old cars were equipped with 4 ceiling lights each and with 32 C P lamps.

Several interesting experiences with this early system of train lighting are told by H. F. Newland, engineer and electrician of the Union Station in Chicago, and formerly a motive power engineer on the L. B. & S. C. R., who was in charge of some of these old train lighting systems and who made some of the original drawings of part of this apparatus. He explained that such instruments as ammeters and voltmeters were unknown at that time and that a pilot lamp was the only indication of the amount of current or voltage generated. Between Brighton and London there are some five or six tunnels, one, the Clay-



One of the Early Types of Train Lighting Generators Used on the London, Brighton & South Coast Ry.

ton, being about two and one-half miles long. It was the custom on a certain daylight train for the head guard to switch the lights on while the train was passing through the tunnels. On one occasion of special importance, it happened that the pilot lamp was burned out and the guard naturally switched on the light when the train left the terminal and, not knowing that the pilot lamp was defective, he switched off the lights when traveling



Wiring Connections and Double Throw Switches for Operating the Train Lights

through the tunnels. An official from the Great Eastern, riding on this train, reported that electrical lighting of trains was a failure. At that time there was but one switch so that the dynamo was either charging batteries or lighting the lamps.

Operation

Normally, the double-throw switch *E* would be thrown to *B* and the switch *C* closed, so that dynamo *D* would be charging the accumulator and the latter serving the lights. Should the pilot light *P* show excessive voltage, switch *C* was opened. Should the pilot light be dim, the double-throw switch was thrown to *A* and switch *C* closed. To cut out lights, switch *E* was thrown to neutral position.

Electrification of English Railroads

THE preliminary report of the Electrification of Railways Advisory Committee in England was published in the November, 1920, issue of the *Railway Electrical Engineer*. The final report has now been published in pamphlet form.

The committee was appointed by the Ministry of Transport in March, 1920, to consider and advise:

1. Whether any regulations should be made for the purpose of insuring that the future electrification in this country is carried out to the best advantage in regard to interchange of electric locomotives and rolling stock, uniformity of equipment or other matters.
2. If any such regulations are desirable, what matters should be dealt with and what regulations should be made.
3. How far it is desirable, if at all, that railways or sections of railways already electrified should be altered so that they may form parts of a unified system.

Subsequently in October, 1920, the terms of reference were extended as follows: To consider and advise—

1. Whether any regulations should be made to limit the drop of potential in an uninsulated return conductor on electrically operated railways.
2. If any such regulations are desirable, what limits these should impose and under what conditions.

The committee in its final report now desires to confirm the recommendations contained in its Prelimary Report. The final report is remarkable for its brevity and the following excerpts from the report are worthy of especial attention:

"The committee desires to add to the preliminary report that from the evidence which has been put before them, as well as their own experience, they have come to the conclusion that alternating current supplied to the substations at a frequency of 50 cycles can be used for railway purposes without any detriment to railway working.

"In respect to contact rail collection, it is essential for the interchange of electrically operated trains that the contact rails should be so placed as to enable current to be collected by the same trains both on railways employing 1,500 volts and on those employing 600/750 volts. The top-contact type of rail is that now generally in use for the present low voltages; the under-contact type of rail has also been largely used, and, in the opinion of the committee, possesses advantages in regard to interference by the accumulation of ice and snow, and also in regard to the arrangement of protection for men working on the track with higher voltages. Suitably designed shoe can be run interchangeably with either the top or under-contact type of rail. Under these circumstances the committee is of the opinion that the contact rails employed may have either a top-contact or an under-contact surface, and it does not consider it desirable to recommend the exclusive use of either type, some varieties of which may be the subject of patents, but think that the choice in this respect should be left open, subject to the regulations below, so as not to interfere with such future improvements as are likely to be developed in either or both types.

"With regard to the practicability of further standardization of equipment by regulations, the committee desires to confirm the views expressed in Clause 10 of the Interim Report to the effect 'that such regulations should put no avoidable difficulties in the way of the adoption in future, with the approval of the minister, of any improvements in methods or appliances which may from time to time become available with increasing knowledge and experience,' and to add that the committee does not consider it desirable, in the interests of railway electrification, that further regulations (other than those recommended in this report) should be issued for the time being.

"With regard to the extended references 1 and 2, the committee, after careful consideration, finds that:

"(1) The evidence given by the railway companies operating electric railways indicates that the cases of harmful effects due to a drop in potential substantially in excess of that allowed by Tramway Acts in earthed railway conductors have been few and unimportant, and readily corrected by the railway companies themselves on their own initiative.

"(2) The clauses for the protection of observatories inserted in the Acts of Railway Companies applying for powers to operate their railways electrically have had, and continue to have, a retarding effect on railway electrification. The committee having heard in evidence officers concerned with the observatory instruments likely to be affected by the operation of electric railways, are of the opinion that the interests of observatories would in any case be sufficiently protected if the scope of the clauses referred to were limited to the portions of electric railways within the vicinity of the observatories.

"Having regard to these considerations and to the views expressed in Clause 10 of the Interim Report, as well as to the difficulties in imposing any definite limit to the voltage drop owing to the variety of conditions which present themselves along different portions of any railways, the committee therefore recommends that:

"(1) It is not desirable that regulations should be issued to limit the drop of potential in an uninsulated return conductor on electrically-operated railways.

"The recommendations are briefly summarized in the following:

"Standard system of power generation—Three-phase alternating current.

"Standard system of power distribution—Direct current.

"Standard pressure—1,500 volts at substation busbars; in special cases a multiple or sub-multiple of 1,500 volts, if approved by the minister.

"Standard collection—Contact rail or overhead contact wire.

"Contact rail standards—Top-contact or under-contact rail, with the contact surface in a horizontal plane installed at a gage of 1 ft. 4 in. from the gage line of the nearest track rail.

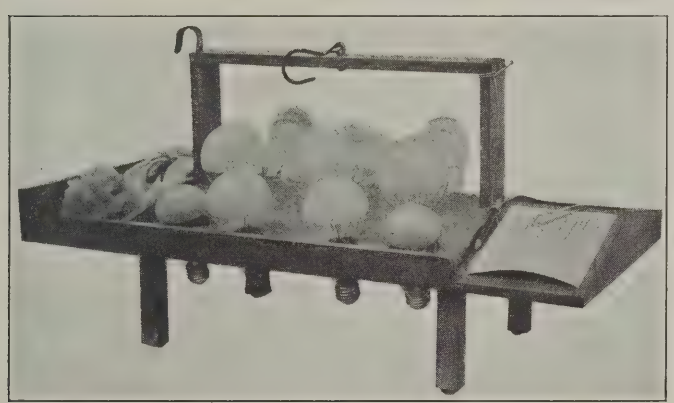
"Overhead contact wire standards—Installed normally over the centre of the track at a height of 3 ft. above the maximum load gage likely to be used on the line, and at a maximum height of 20 ft. above track rail level.

"Limitation of drop in earthed return conductors—No regulations to be issued."

THE INTERCHANGE

A Lamp Maintenance Rack

The maintenance of lamps in shops, stations, and various other installations both indoors and outdoors is something which is very likely to be neglected unless the work is performed on a regular schedule. In other words, systematic maintenance work is the sort of maintenance which makes for lighting efficiency. And efficiency in any line depends to a very large extent upon the right kind of tools to perform the best work with the least amount of time and labor. Lamp maintenance does not differ in this respect from other classes of work and the lamp rack shown in the photograph indicates one way in which lamp inspection may be rendered more



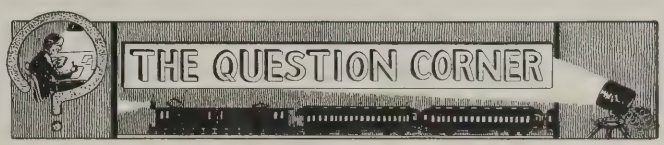
Rack Loaded and Ready for Inspection Trip

efficient. In a recent issue of the Electric Journal a writer describes this rack as an important adjunct in the lamp maintenance of a large textile mill. It is not important that this carrying rack conform closely to the shape or size of the one illustrated—the main thing is to have a tray of some kind for the purpose of transporting lamps to and from the stock room and at the same time provide space for cleaning materials and a record sheet, as indicated in the picture. Any ambitious lamp man should be able to construct for himself a convenient form of rack which combines these features, which make for expedient and efficient lighting maintenance.

Honking your horn doesn't help so much as steering wisely.

Don't expect poor work now to lead to brilliant work hereafter.

You have no idea how big the other fellow's troubles are.



Answers to Last Month's Questions

Assume that each lamp in Fig. 1 *takes* 2 *amperes and that the resistance of the lamps remains constant. The brush potential of each generator is* 112 *volts. Find* (*a*) *the line drop in each section,* (*b*) *the voltage across each set of lamps,* (*c*) *the power delivered by G*1 *and G*2. *If a break should occur in the neutral between O and S, what would be the values of* (*a*), (*b*) *and* (*c*)*?*

If a break should occur in the neutral between S and V, what would be the values of (*a*), (*b*) *and* (*c*)*?—C. B. F.*

* * *

The above problem, the solution of which follows, is perhaps not so difficult as it is lengthy. There are a number of points, however, which are well worth emphasizing and for this reason very full and complete explanations have been made. As a matter of fact the problem is really a number of problems, each of which brings out some very interesting and instructive points in connection with

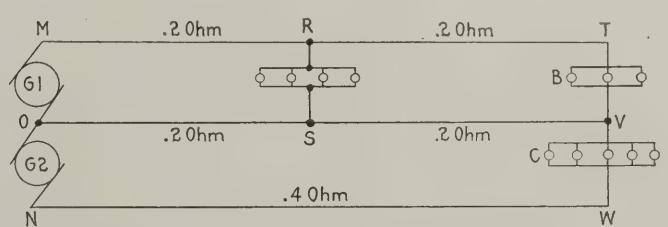


Fig. 1—Showing Conditions of the Problem

the Edison three-wire system of wiring. We hope, therefore, that those readers who are particularly interested in wiring problems will file away, mentally or otherwise, for future use the information presented herewith.

* * *

Referring to Fig. 1, let us first determine the current flowing in each portion of the circuit. Since it is stated in the problem that each lamp takes 2 amperes, it is clear that the current flowing in the line between *M* and *R* will be the total current required by the 7 lamps located at *A* and *B*, or 14 amperes. It is also plain that the current in the line between *R* and *T* will be 6 amperes. Similarly the current in the line *NW* will be 10 amperes.

It is desirable to determine the direction of the current flow in the different portions of the circuit, and in order to do this let us assume that the potential of the point *M*

is 112 volts above zero. The point N may likewise be assumed to be 112 volts below zero, and the neutral point O between the two generators will then be taken as zero. These assumptions having been made, the amount and the direction of current will be as shown in Fig. 2.

Since 14 amperes flow from the point M, and only 6 amperes beyond the point R, it is evident that 8 amperes flow from R to S. This current of 8 amperes divides at S, 4 amperes flowing from S to V, where they combine with the 6 amperes flowing from R to T, through the lamps B to V, thus making the 10 amperes required by the lamps C. These 10 amperes return to the generators over the line NW. The current in the line OS will be the 4 amperes remaining after the current of 8 amperes through the lamps A has been divided at the point S.

The line drops in the various sections and may then be computed from the formula $E = IR$, as follows:

M to $R = 14 \times .2 = 2.8$ volts, R to $T = 6 \times .2 = 1.2$ volts

O to $S = 4 \times .2 = .8$ volt, S to $V = 4 \times .2 = .8$ volt

N to $W = 10 \times .4 = 4$ volts

The voltage across each set of lamps may be determined by finding the potentials of the points R, S, T, V and W. Since the drop from M to R is 2.8 volts and the point M has a potential of 112 volts, it follows that the potential of R is $112 - 2.8 = 109.2$ volts.

Again, since the line OS has a potential of zero at the generator end and at the same time has a line drop of .8 volt, it is clear that potential of the point S will be .8 volt. The difference then between the potential at R and the potential at S will be the voltage across the A set of lamps.

$109.2 - .8 = 108.4$ volts across the A set of lamps. The potential of the point T will be equal to the potential of M, minus the sum of the line drops in MR and RT:

$$112 - (2.8 + 1.2) = 108 \text{ volts potential at } T$$

From the direction of current flow in the line SV, we know that the potential of the point V must be less than the potential at S. The potential at S is .8 volt, and if we

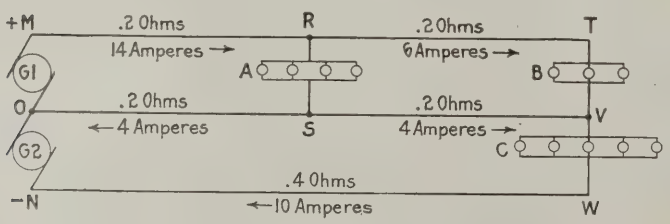


Fig. 2—Indicating the Amount and Direction of the Current in the Various Branches

take from this the line drop in SV, which is likewise .8 volt, we find that the point V is at zero potential.

$$.8 - .8 = 0 \text{ volts potential at } V$$

It is obvious, therefore, that the voltage across the B set of lamps is 108 volts.

In a similar manner the potential of the point W may be shown to differ from the potential of the point N by an amount equal to the line drop in the line NW. In this case, however, since the current flows from W to N, it is evident that the point W is at the higher potential. In other words, by *adding* the line drop to the potential of N we have the potential of W.

$$-112 + 4 = -108 \text{ volts potential of } W$$

It must be remembered that while both N and W have negative potentials, the potential of W is positive with respect to N. Since the point V is at zero potential the voltage across the C set of lamps is 108 volts.

In determining the power delivered by the generators the formula $W = E\,I$ should be used and the generators considered separately. As the voltage of each generator is 112 volts, the only variable factor is current. For generator $G1$ the current is 14 amperes, hence the power delivered by this generator is

$$112 \times 14 = 1{,}568 \text{ watts}$$

In the same way the power delivered by $G2$ is

$$112 \times 10 = 1{,}120 \text{ watts}$$

Part 2

The second part of the problem, which assumes a break in the line between O and S, changes the original conditions considerably. It would be incorrect to assume a current of 2 amperes for each lamp if we assume a voltage of 112 for each of the generators. We, therefore, assume the generator voltage to remain at 112, and de-

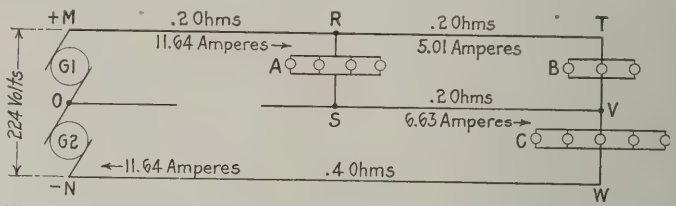


Fig. 3—Diagram Shows Amount and Direction of Current if the Neutral Wire is Opened Between O and S

termine what current would flow in the circuit under the changed conditions. Fig. 3 shows the new arrangement. It will be seen that the two groups of lamps A and B are in parallel with each other and that this combination is in series with the C group of lamps.

The first step is to determine the resistance of the several groups of lamps. This may be done by using results obtained in the first part of the problem. We found that the voltage across lamp group A was 108.4. Then by using the formula $R = \frac{E}{I}$, the resistance of lamp group A is $\frac{108.4}{8} = 13.55$ ohms.

In the same manner the resistance of group B is found to be 18 ohms, and of group C, 10.8 ohms.

Then the resistance from R to V through the lamp group A is $13.55 + .2 = 13.75$ ohms. And from R to V through the lamp group B is $18 + .2 = 18.2$ ohms.

The joint resistance of these two paths in parallel is given by the formula

$$R = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2}}$$

Where R = Joint Resistance

r_1 = resistance of group A lamps + .2 ohms

r_2 = resistance of group B lamps + .2 ohms

Substituting the numerical values previously obtained we have

$$R = \frac{1}{\frac{1}{13.75} + \frac{1}{18.2}} = \frac{1}{\frac{31.95}{250.25}} = \frac{250.25}{31.95} = 7.832 \text{ ohms}$$

The resistance of lamp group C, which is 10.8 ohms, together with the line resistances between M and R and between N and W, should now be added to the joint resistance of the parallel circuits with the following result:

$10.8 + .2 + .4 + 7.832 = 19.232$ ohms total resistance between M and N.

The two generators $G1$ and $G2$ must now be considered in series as developing 224 volts. This voltage, then, with a resistance of 19.232 ohms in the circuit will cause to flow a current of

$$224 \div 19.232 = 11.64 \text{ amperes}$$

On reaching the point R this current divides inversely as the resistance of the two parallel circuits from R to V. Now 13.75 ohms is the resistance through the A group of lamps and 18.2 ohms is the resistance through the B group of lamps. Then since the conductances of the two branch circuits are inversely proportional to their resistances

$$\frac{1}{13.75} = \text{the conductance through the } A \text{ group of lamps}$$

$$\frac{1}{18.2} = \text{the conductance through the } B \text{ group of lamps}$$

Their sum equal the joint conductance of the two circuits between R and V.

$$\frac{1}{13.75} + \frac{1}{18.2} = \frac{18.2}{250.25} + \frac{13.75}{250.25} = \frac{31.95}{250.25}$$

Then the current through the A group of lamps would be

$$\frac{18.2}{31.95} \times 11.64 = \frac{211.848}{13.95} = 6.63 \text{ amperes}$$

and through the B group of lamps, the current would be

$$\frac{13.75}{31.95} \times 11.64 = \frac{160.05}{31.95} = 5.01 \text{ amperes}$$

Knowing the current in the various parts of the circuit the line drop may be computed from the formula $E = IR$

Drop in $MR = 11.64 \times .2 = 2.328$ volts
" " $RT = 5.01 \times .2 = 1.002$ "
" " $SV = 6.63 \times .2 = 1.336$ "
" " $NW = 11.64 \times .4 = 4.656$ "

Since the resistance of each group of lamps is known the same formula may be used to determine the voltage across the several groups.

Voltage across group $A = 6.63 \times 13.55 = 89.8365$ volts
" " " $B = 5.01 \times 18. = 90.18$ "
" " " $C = 11.64 \times 10.8 = 125.712$ "

Since the generators are in series each is doing an equal share of the work, the total generated voltage being 224. The total current is 11.64 amperes and hence the total power would be

Watts = voltage $\times$ current $= 224 \times 11.64 = 2607.36$ watts.

Then each generator would deliver one-half of this amount or 1303.68 watts.

Part 3

The third section of the problem involves further changes of conditions as shown in Fig. 4. Here it will be seen that generator $G1$ in addition to assisting generator $G2$ in supplying current to lamp groups B and C, is alone supplying all of the current for lamp group A. The voltage of each generator is assumed to be held constant at 112 volts or 224 volts from M to N.

In order to determine the current in the various parts of the circuit we may make use of the resistances of the several lamp groups as previously determined. The resistance through the circuit M-R-T-V-W-N includes both line resistance and lamp resistance and may be summed up as follows:

$$.2 + .2 + 18 + 10.8 + .4 = 29.6 \text{ ohms}$$

The current in this circuit will then be

$$224 \div 29.6 = 7.567 \text{ amperes}$$

Since the lamps of group A must be supplied with current over the line MR, it is evident that this section of line will carry current in addition to the 7.567 amperes.

To find what this current is we may consider the circuit through the lamp group A as if it were by itself being supplied by the single generator $G1$. We know that the resistance of the lamp group A is 13.55 ohms and hence the resistance from M to O through this group is

$$.2 + 13.55 + .2 = 13.95 \text{ ohms}$$

The current passing through group A will then be

$$112 \div 13.95 = 8.028 \text{ amperes}$$

The current in the line MR will then be

$$7.567 + 8.028 = 15.595 \text{ amperes}$$

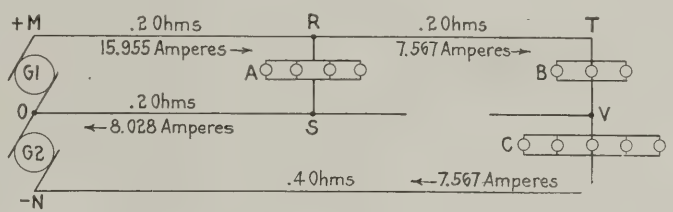


Fig. 4—Diagram Showing Amount and Direction of Current When Neutral Wire is Broken Between S and V

The line drop in the various line sections will be as follows:

Drop in $MR = 15.955 \times .2 = 3.191$ volts
" " $RT = 7.567 \times .2 = 1.5134$ "
" " $OS = 8.028 \times .2 = 1.6056$ "
" " $NW = 7.567 \times .4 = 3.0268$ "

The voltage across the various lamp groups may be determined in the same way since we know the resistances of the several groups.

Voltage across group $A = 8.028 \times 13.55 = 108.779$ volts
" " " $B = 7.567 \times 18. = 136.206$ "
" " " $C = 7.567 \times 10.8 = 81.723$ "

The power delivered by each generator will be the product of that generator voltage by the current passing through it.

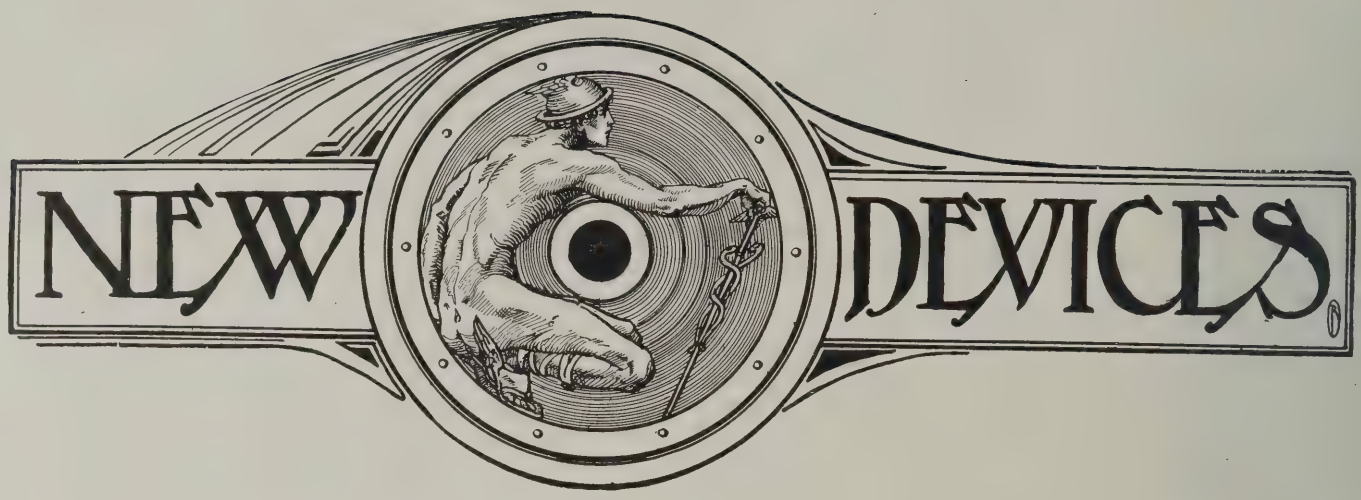
Power delivered by $G1 = 112 \times 15.955 = 1786.96$ watts
" " " $G2 = 112 \times 7.567 = 847.5$ "

Questions for December

1. Can you tell me why it is that large knife switches designed for carrying currents of over 2000 amperes have a different capacity rating for direct current than for alternating current?—M. M.

2. What is the easiest way of connecting two batteries through a switch so that they may be charged in series and discharged in parallel?—C. J. S.

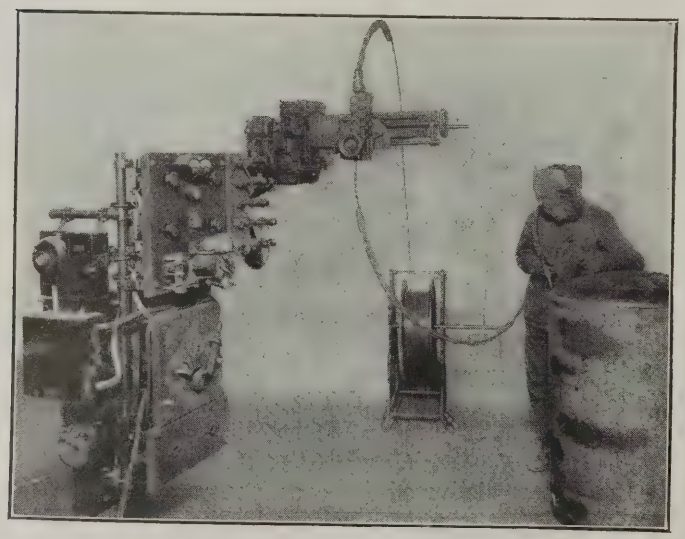
3. Does the ampere hour efficiency of a lead storage battery differ when charged at high and low rate?—J. E. R.



Semi-Automatic Arc Welding Lead

A semi-automatic arc welding lead has just been developed by the General Electric Company, Schenectady, N. Y., for use in conjunction with its automatic arc welding head, which retains the continuous features of the automatic apparatus, yet allows the operator to direct the arc as required by the conditions of the work.

The apparatus consists of a welding tool to be held by the operator, which acts as a guide for the electrode wire. In the handle of the tool, which greatly resembles an automatic pistol, is a switch for operating the control on the panel of the automatic welder to start and stop the



General Electric Semi-Automatic Arc Welder

movement of the electrode wire. Attached to the tool is a 10-ft. length of flexible steel tubing, called the "flexible wire guide," with an adapter on the other end for attaching it to the automatic welding head. The wire passes from the feed rolls of the head into the flexible tubing, and thence to the arc through a "guide nozzle" in the welding tool. The automatic welder functions in its accustomed manner, tending to hold the arc length constant, and the operator merely directs the arc as required by the particular job in hand.

The field of application of the semi-automatic lead is the welding of products where the seams to be welded are of very irregular contour, or on very large work where the travel mechanism and clamping necessary for the full automatic welder would be complicated and costly. In many cases the edges of the seams are not accurately prepared, making gaps in some places and tight fits in others. The automatic welder with mechanical travel cannot compensate for these conditions by varying the speed, or by manipulation of the electrode, but with the semi-automatic, they are taken care of.

The semi-automatic welder may also be used for building up metal rapidly, as in the case of the filling up of blow holes in castings, or the building up of worn spots, etc. The speed of deposition of the metal varies widely, being somewhere between the ordinary hand speed and that of the automatic, according to the conditions of the particular job. In general it is about twice as fast as hand welding.

The advantages claimed for the automatic welding equipment may be summed up as follows: (1) Saving in time which is ordinarily lost in changing electrodes; (2) saving of from 10 to 20 per cent in electrode material ordinarily thrown away as waste ends; (3) operators can become proficient in the use of the tool very quickly, as they do not require the muscular training necessary for hand work (4) continuous operation results in few interruptions in the welding, each of which is a potential source of defective welds.

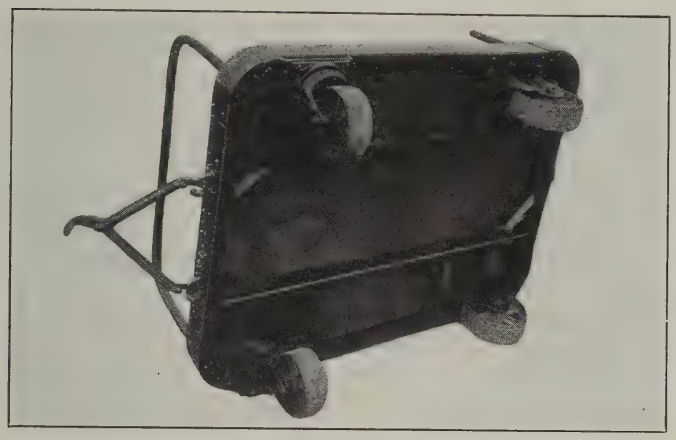
Heavy Duty Trailer for Concentrated Loads

The movement of heavy concentrated loads, such as large castings, etc., constitutes an important handling problem in railway freight stations, warehouses and repair shops. In such work, cranes, trucks, tractors and trailers and various other material handling devices are being increasingly used. For such work the Sharon Pressed Steel Company, Sharon, Pa., has developed a trailer specially designed for heavy duty service with tractors.

The trailer frame consists of four ⅜-in. channel sections which are pressed from ⅛-in. hot rolled open-hearth steel and riveted into one-piece channel section corner pieces pressed to a 6-in. radius. By varying the length of the side and the end rails, the trailer can be made in any length up to 72 in., and in any width up to 50 in. Two additional members, of 3-in. pressed steel channel, run lengthwise beneath the floor and are riveted to the

end rails and braced, laterally, to the frame with front and rear pressed steel "V" braces which take the pull of the 5/8-in. steel forged coupler. Either one or two couplers can be used.

The rear wheel and front caster supports are 3-in. pressed steel channels riveted to the side rails and the longitudinal members of the frame. The rear wheel brackets are pressed from 1/4-in. steel, with two stiffening ribs on each side. The rear wheels are of malleable iron with six double-web spokes and 3½-in. face and are



Under Platform View Showing Construction Details

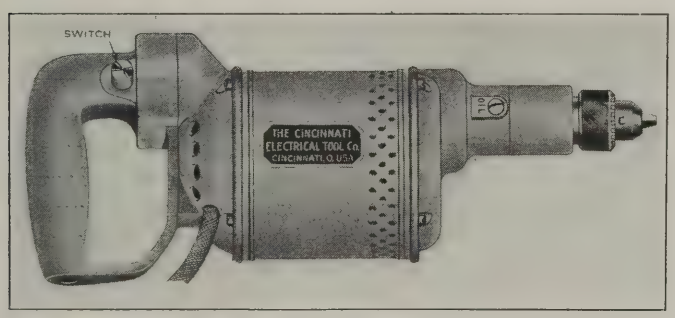
equipped with 3-in. Hyatt roller bearings on a hardened and ground 1-in. shaft.

The front casters are of heavy-duty type, ball and roller bearing equipped, bolted to a ½-in. steel plate which is riveted to the frame. The floor of the trailer is 1¼-in. oak recessed flush in the side and end rails. All frame members are flush on the bottom, thus affording an even support when the trailer is used in connection with a lift truck, such as is now coming into quite common use.

The trailer was recently given a severe test with a load of 8,000 lb., indicating its adaptability to exact service.

Ease of Operation Features New Portable Drill

A lightweight, portable electric hand drill of 3/16-in. capacity with pistol grip is the latest addition to the line of portable electric drills and grinders manufactured by the Cincinnati Electrical Tool Company, Cincinnati, Ohio.



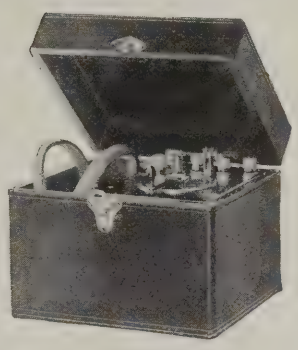
Portable Electric Drill With Pistol Grip

This new drill answers the need for a light and practically frictionless but high speed and powerful tool, adaptable to all kinds of light drilling. It is suitable for drilling in steel, brass, aluminum and sheet metal and for car building, window frames, etc. It also makes a very practical tool for wood boring.

While thoroughly simple in construction, the new drill is compactly and substantially built. It is equipped with a universal motor for use on direct and alternating current of the same voltage. The motor housing, end caps and handle are made of special aluminum, insuring minimum weight consistent with strength. The armature and gear studs are mounted on ball bearings which practically eliminate friction. Gears are of special analysis high grade steel. The switch is the Cincinnati quick make-and-break type with 50 per cent overload allowance. It is entirely enclosed in the handle and is operated by a trigger conveniently located in the handle.

New Radio Receiving Set

The latest development in radio receivers has just been placed upon the market by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., under the trade name of Aeriola Jr. This is a complete radio receiving outfit which weighs only five pounds, and may be carried with ease. To use this outfit it is only necessary to connect it to a single-wire aerial and a ground. No additional equipment is needed, for the receiver includes all the essentials—a variable tuner, a fixed condenser, a supersensitive crystal detector, and a high grade set of head phones.



Radio Receiving Set

This outfit is a single-circuit receiver, involving a variometer tuner with fixed series condenser. The detector is sensitive at all points and is said to give easy and dependable operation. A single indicating arm operating over a graduated dial assures quick and accurate tuning for telegraph or telephone stations within its range of 190 and 500 meters wave length.

The head phones are connected to the usual stopping condenser. A special compartment is provided in the case for the head phones, so that the unit is complete and ready for instant use. Bulletin No. 4465 illustrates and describes this unit.

Appliance Plugs and Switches.

The General Electric Company, Schenectady, N. Y., is manufacturing and marketing an attaching plug for connecting the cord in the handle of vacuum cleaners to the motor. This plug has a one-piece body and the binding screws on both sides of the base are covered by a fibre insulating sleeve. The contacts in the live end of the plug are concealed and out of the way of accidental touch. A motor plug for use in the body of motors, all made of composition, is also manufactured by the same company. The contacts on the free half of the plug are concealed, thus giving the same element of safety as the other type. Strong bent contact fingers make it possible for the cap to fall off, and the base of the plug is held in the motor frame by grooves. A fibre separator in the bottom half of the plug is a precaution against short-circuiting. The use of either type makes it possible to remove the handles in packing for shipping.

General News Section

A district sales office has been opened by the Square D Company, Detroit, manufacturers of inclosed switches, at 312 International Life Building, St. Louis. J. D. Utley has been appointed office manager, while W. S. Herman is district sales manager.

M. I. Scott, for some time in charge of crane-motor production with the General Electric Company at Fort Wayne, Ind., has been transferred to the Erie (Pa.) works of the company. Crane-motor production in the future will be carried on there. W. H. Kellermeyer is taking Mr. Scott's place at Fort Wayne.

The Okonite Company, Passaic, N. J., has opened a branch office at Atlanta, Ga., in the Candler Building, with E. A. Thornwell as southeastern sales representative, and John L. Phillips as manager. The territory covered by this office will be North and South Carolina, Georgia, Alabama, Florida, Tennessee, and the city of New Orleans, La.

The Delaware, Lackawanna & Western has again asked the General Electric Company and the Westinghouse Electric & Manufacturing Company to prepare estimates for the electrification of about 40 miles of gradients near Scranton, Pa. The work will cost over $5,000,000 and has been contemplated for some time. Bids were received for the work last summer, but these were all rejected.

Stockholders of the Pullman Company will hold a special meeting in Chicago on December 20, to vote on the following amendments to the charter of the company:

Increasing the capital stock from $120,000,000 to $135,000,000 and increasing the number of directors from nine to twelve and electing the same. To authorize directors to purchase all assets of the Haskell & Barker Car Company, Inc., and pay therefor $275,000 in cash and 165,000 shares of the capital stock of the Pullman Company, and in case of adoption of the amendment increasing capital stock, authorize the board to issue and deliver direct to the Haskell & Barker Company 150,000 shares of the increase.

The $275,000 cash payment is equal to $1.25 a share on the Haskell & Barker stock, which, it is expected, will be distributed as an extra dividend.

U. S. Light & Heat Not Involved in Willys Corporation Receivership

The recent receivership of the Willys Corporation has caused some inquiries to be made of the U. S. Light & Heat Corporation, Niagara Falls, N. Y., as to what effect, if any, the proceedings will have respecting the latter company; and certain publicity in connection with the receivership has erroneously carried the idea that the U. S. Light & Heat Corporation is one of the component parts of the Willys Corporation and would, therefore, be affected in its operation by the receivership. These inquiries have led C. O. Miniger, president of the U. S. Light & Heat Corporation, and who is one of the receivers appointed by the U. S. District Court at Toledo, to make the statement that the receivership in no way affects the business of the U. S. company. His appointment as receiver was made by virtue of his connection with the Electric Auto Lite Company of Toledo, which company is one of the divisions of the Willys Corporation.

The only connection between the Niagara Falls company and the Willys Corporation is that of preferred stock ownership by the Willys Corporation. The corporations and the managements are entirely distinct and the operation of the U. S. L. Company will continue exactly as heretofore.

Gas to Be Abolished on French Trains

M. le Trocquer, Minister of Public Works of France, has sent a circular letter to all railway companies instructing them to take immediate steps to abolish the use of gas in the lighting of trains. Gas lighting, he says, must be abolished on all express trains by January 1, 1923, and on all suburban trains by January 1, 1924. Returns are to be called for from railway companies showing from time to time how far the transformation of the lighting system has progressed. Coal fires for the heating of trains are to be done away with within a period of two years. The letter concludes by asserting that the directors of the companies will be held personally responsible in the event of accidents in any way attributable to neglect of this admonition. This is a sequel to the Batignolles tunnel accident, in which several coaches of a train caught fire and many persons were killed.

Paulista Railways Begin Electric Operation

The freight locomotives recently shipped by the Westinghouse Electric & Manufacturing Company to the Paulista Railways of Brazil are now in service in that country between Jundiahy and Louveira. These are the first electric locomotives to be used in Brazil, and the inauguration of electric service there represents an important step in the future electrification of South American railroads.

The new locomotives haul trains of from 43 to 45 units over grades as steep as 1.5 per cent. The so-called "unit car" is of 10 tons gross weight, and the term refers to the old wooden car of thirty years ago. Modern cars are said to be two, three or four units, according to their size and load. Thus a train of 45 units represents 450 tons weight and is approximately 675 feet in length.

Under former steam operation such trains could not be carried over a 1.5 per cent grade at a speed greater than nine or ten per hour. Electric locomotives make such grades at 29 miles per hour.

Japanese Railway Activity

An indication of the improvement in business conditions in Japan since the 1920 critical financial stress of that country is received from the recent placing of an order with the Westinghouse Electric & Manufacturing Company for substation material amounting to $76,000. This order covers the complete equipment for two substations and includes eight rotary converters, twelve transformers, two complete switch gear equipment, and station lighting transformers.

Other large orders for railway material recently have been placed in this country by the Seto Electric Railway Company, the Bisai Electric Railway Company, the Nagasaki Electric Railway Company, the Tokio Municipality and by other large Japanese railway operating companies and municipalities.

Spanish Northern Railway Electrification Project

A contract for the electrification of forty miles of the Spanish Northern Railway is announced by the Sociedad Iberica de Constructiones Electricas, of Madrid, Spain, one of the associated companies of the International General Electric Company, Inc., of New York. This initial order constitutes the most recent and one of the largest European railway electrification projects now under development. The high voltage direct current system will be used.

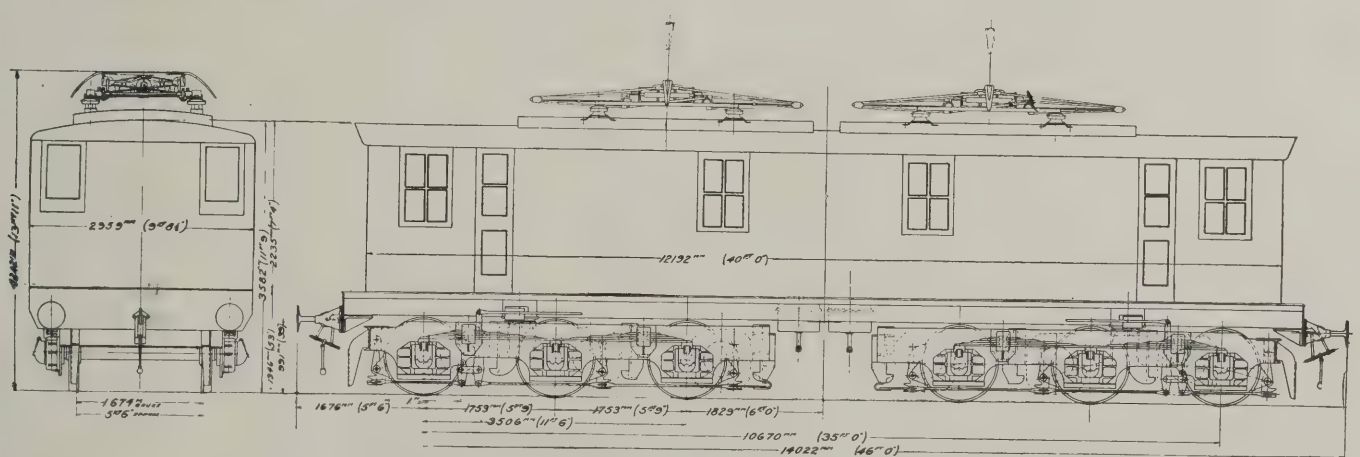
The equipment to be supplied by the Sociedad Iberica de Constructiones Electricas will consist of six 78-metric ton, six motor locomotives, two complete sub-stations, each comprising two 1,500 kilowatt, three unit motor generator sets, transformers and switchgear and the material necessary for line construction.

The first electrification project of the Spanish Northern comprises about forty miles of the Leon-Gijon line running through the mountains between Ujo and Busdongo. Although this is a single-track line, traffic is extremely heavy, as it is a link between the mining district and the northern seaboard through a mountainous region with many tunnels, considerable grades and severe climatic conditions.

The electric locomotives on order will be of the freight type, with the following dimensions:

Length over bucklers	46 feet
Height	13 feet, 11 inches
Width of cab	9 feet, 8 inches
Rigid wheel base	11 feet, 6 inches
Maximum wheel base	35 feet

The locomotives will be arranged for regenerative braking, and will operate at 3,000 volts. The locomotive speed at continuous rating is 13.5 miles an hour. Pantograph collectors will be used similar to those on the St. Paul locomotives, having a double contact shoe.



End View and Side Elevation of One of the Locomotives to Be Used In Spain

Proposal to Develop Colorado River Power for Railroad Electrification

Two applications for preliminary permits were received by the Federal Power Commission during the week ended November 26. Guy P. Mohler, of Needles, Ariz., requests a permit covering a location on the Colorado River in Mohave County, Ariz., and Clark County, Nev. He wishes to erect a series of dams beginning at Pyramid Peak at the lower end of Pyramid Canyon and extending upstream to the proposed projects of the city of Los Angeles and of E. L. Beyard in Boulder Canyon. The available power is estimated to be 316,800 horsepower, and it is proposed to build a plant of 400,000 horsepower installed. The power is for railroad electrification.

Benjamin H. Hardaway of Columbus, Ga., requests a preliminary permit to cover a 1,400 horsepower project on Pea River near its mouth for public utility uses.—*Electrical World.*

Wireless Telephone in China

The introduction of wireless telephony in China, according to Professor C. H. Robertson, a noted American lecturer, has aroused tremendous interest in that country. Professor Robertson has been demonstrating the radiophone in China and Japan during the past six months, where it is estimated that at least 300,000 people have attended his lectures on this subject. He found the easiest way to interest the

Asiatic was to take his wireless telephone station through the streets of a crowded city on a big Chinese wheelbarrow, stopping now and then to carry on a wireless conversation with one of his associates located at their quarters.

Personals

Alfred Roland Van Horn died on October 25 after a protracted illness of nearly two years. Mr. Van Horn was an inventor of electrical appliances, one of which was an automatic control for isolated power plants. He was engaged in the manufacture of this machine with the Trumbell Electric Manufacturing Company of Plainville, Conn., until his illness caused him to stop active work. Born in Philadelphia in 1886. Mr. Van Horn attended the Pennsylvania State College and Drexel Institute for two years each. After three years of engineering experience in a partnership, he started his experimental work in 1911, and continued in that line, becoming in 1919 an engineer with the Trumbell Company, which had bought the manufacturing right to his device. During the war ill health kept Mr. Van Horn from passing the physical examination for the army, but he did construction work at the Hog Island navy yard and also at one of the stations of the Philadelphia Electric Company.

William Edgar Baker died suddenly of heart disease at 50 East Fifty-eighth street, New York city, on November 7, 1921. Prominent in both the civil and electrical engineering fields, Mr. Baker had retired from active business in recent years. He was born at Springfield, Mass., in 1857, and was graduated from Lafayette College in 1877. He then entered the service of the Canadian Pacific Railroad under such conditions of hardship that few survived, but soon showed his ability. In 1884 he left this to become resident engineer for the International & Great Northern Railway, in Texas. Four years later he began his career as electrical engineer, accepting appointment as superintendent in charge of the installation of electricity on the West End Street Railway System of Boston. From 1892-94 he designed and built the Columbian Intramural Railway in Chicago, a work which brought him into prominence both in this country and in Europe. During the next five years he was general manager and chief electrical engineer of the Metropolitan West Side Elevated Railroad in Chicago. In 1899 he came to New York to accept the same position with the Manhattan Elevated Railroad, operating the railroad as its general manager until he resigned and opened an office in New York as consulting engineer.

Trade Publications

The Shepard Electric Crane & Hoist Company, Montour Falls, is distributing a leaflet describing its "Liftabout," a small general utility hoist.

The Jewell Electrical Instrument Company, 1640-50 Walnut street, Chicago, is distributing a pocket memorandum book, entitled the "Jot Book," in which it describes several of its electrical instruments.

Two new bulletins have recently been prepared for distribution by the Philadelphia Storage Battery Company, Philadelphia, Pa. They are printed in colors and present respectively the inside story of the battery, which consists of a description of the construction of the cell, and the use of the storage battery in industrial plants haulage.

Cutting the Unreckoned Costs is the name of a small 10-page booklet recently published by R. D. Skinner & Company, Inc., New York City. The booklet compares the use of Lion Paw belting with belting of leather, wooster, camels hair, rubber or balata. On pages 6 and 7 is shown a chart illustrating the result of efficiency tests of various types of belting. It is stated that the Lion Paw belting is not only suitable for power drive, but is also largely used for conveying purposes. On the final page of the booklet is given a price list of all sizes from 1 in. to 48-in. in width and in thicknesses varying from single 4-ply to triple 10-ply.

The Sangamo Electric Company, Springfield, Ill., has recently issued its bulletin No. 58, which succeeds bulletin No. 50. The title of the new pamphlet is "Locomotive Type Amperehour Meter." The locomotive type meter has been especially designed to meet the severe requirements found in mine locomotives and electric and industrial truck service. The bulletin gives a complete, detailed and illustrated description of the various parts of the Sangamo amperehour meter. Wiring diagrams are also given as well as a price list of all of the parts required in the assembly of the amperehour meter. The last three pages of the booklet are devoted to a discussion of testing and adjusting this type of meter.

The Gold Car Heating & Lighting Company, Brooklyn, N. Y., has recently issued its 1921 catalogue describing the Gold electric thermostat temperature regulating system for the automatic control of steam, hot water or hot air heating apparatus. The booklet is well illustrated and shows the various types of thermostat control for all kinds of heating equipment. Complete diagrams are given showing the location of the apparatus, as well as the actual connection between the thermostat, motor and furnace. Although the booklet is devoted almost exclusively to describing and illustrating the various equipment and applications for the heating of buildings, the devices used are practically the same as those which are successfully operating in both steam and electric railway coaches.

The Westinghouse Lamp Company, 165 Broadway, New York, in its Bulletin E-101, dated October 1921, gives some very complete information on the subject of illumination values and their treatment. The booklet contains 24 pages and is well illustrated. Of particular interest are tables 1 and 2. The former gives the minimum values of illumination allowable under the typical state factory lighting codes, while the latter gives the present standards of desirable illumination for various classes of service. In table 2 the industries are classified and there are few, if any, lighting conditions which have not been dealt with in the very extensive list presented. A third table shows the grouping of industries and locations according to the present standards of desirable illumination which includes practically the same material as table 2, except that it is arranged according to foot candles instead of alphabetically.

Power

Railway Electrical Engineer

Illumination

Heavy Electric Traction | Train Lighting | Electric Welding

VOLUME 12 | DECEMBER, 1921 | NUMBER 12

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DEC 29 1921

Standardizing on Goodrich

So conspicuous has been the service from Goodrich Axle Lighting Belts that a number of railroads are side-tracking individual specifications and standardizing on this belt.

Three out of four railroads now use Goodrich.

THE B. F. GOODRICH RUBBER COMPANY, *Akron,* OHIO

Goodrich

AXLE LIGHTING BELTS

FOUNDED 1870
TRADE MARK

How Telephone Train Dispatching Increases the Dispatcher's Control of Traffic

Railway executives in charge of communication know by experience that Telephone Train Dispatching is the most rapid, accurate, efficient and dependable means of directing traffic movements.

By means of telephone apparatus at way-stations and sidings and portable instruments for emergency use, the Dispatcher's office can be informed at all times of train movements and is enabled to direct them with greatest safety and economy.

Warnings of dangerous track conditions can be reported immediately. The positions of passenger, freight, wreck and work trains can be made known and orders for their safe and economical movement issued. Overtime is reduced by this close supervision.

Another thing, the personal element introduced by direct contact between the Dispatcher's Office and the train crews and foremen of track and bridge gangs produces more harmonious departmental relations.

Essentially, the Western Electric Telephone Train Dispatching System is a multi-station line on which the stations are called selectively by the Dispatcher's office.

The only limitations to the speedy, accurate distribution of essential information are those imposed by the operator's ability to take down directions. This averages 100 words a minute. Obviously the lessened fatigue and strain imposed on operators lead to more complete reports and make possible a degree of supervision nearer 100%.

For details get in touch with our nearest House.

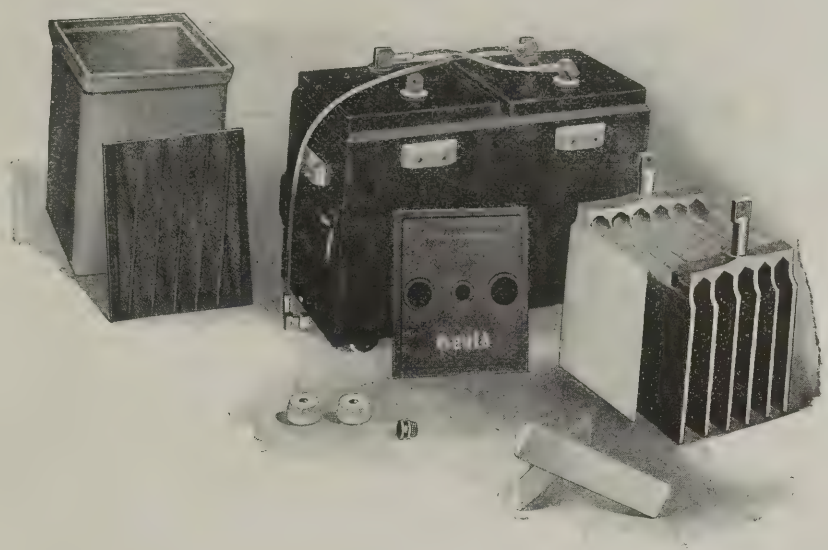
A National Electrical Service for Railroads

Western Electric Company

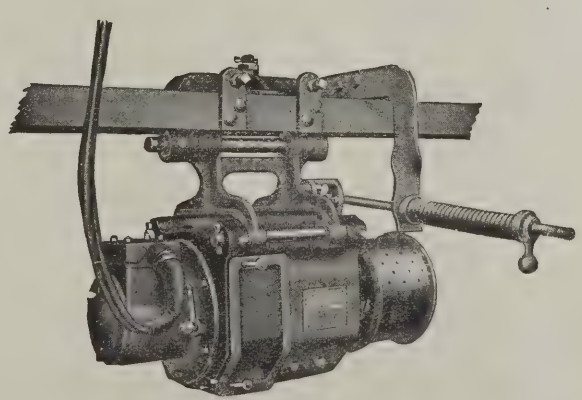
OFFICES IN ALL PRINCIPAL CITIES

Volume 12 Number 12

Published Monthly by Simmons-Boardman Publishing Co., Woolworth Building, New York, N. Y. Subscription price, United States, Canada and Mexico, $2.00 a year; foreign countries, $3.00 a year. Single copies, 35 cents. Entered as second-class matter, January 4, 1916, at the post office at New York, N. Y., under the act of March 3, 1879.



GOULD "SIMPLEX" SYSTEM



STANDARD TRUCK GENERATOR BODY MOUNTED

GOULD COUPLER CO.
GOULD STORAGE BATTERY CO.
New York Chicago San Francisco
Works: Depew, N. Y.

Phono-Electric

—The Answer to Why, is WEAR!

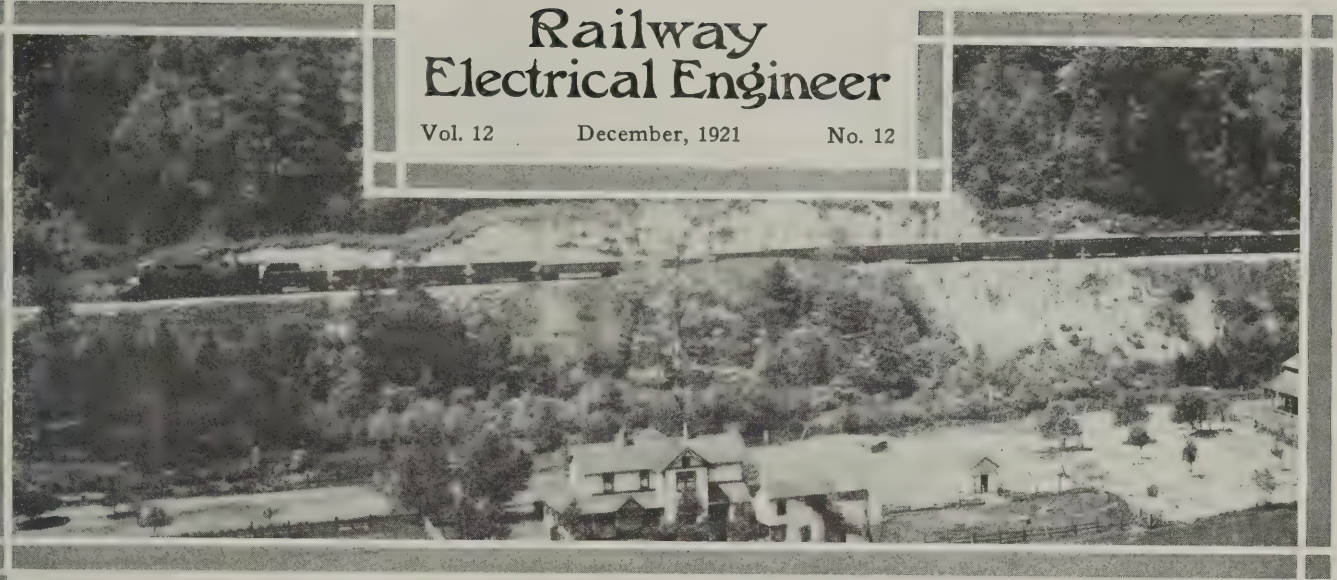
"What a true line," any line engineer will say on examining the overhead work of the Pennsylvania's 11,000-volt Philadelphia-Paoli electrification.

And it will stay true for years to come, despite the almost incessant pounding from the current collectors of high-speed trains, because Phono-Electric trolley wire is a contact wire that is stiff enough to stay in line and hard enough to take the wear.

Bridgeport Brass Company
Bridgeport Connecticut

Railway Electrical Engineer

Vol. 12 December, 1921 No. 12



Freight Train Between Motcake and Rock, W. Va., on the Virginian

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WE GUARANTEE, that of this issue 2,600 copies were printed: that of these 2,600 copies, 2,127 were mailed to regular paid subscribers, 57 were mailed to advertisers, 27 were mailed to employees and correspondents, and 389 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 34,800, an average of 2,900 copies a month.

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The Standard for Rubber Insulating Tape

ONE QUALITY ONLY

Okonite Tape is an unvulcanized rubber compound tape for insulating splices in wires and cables. It is made with the same high-grade rubber, compounding ingredients, and care that characterize Okonite Insulation.

As Okonite Tape is unvulcanized, it readily moulds into a homogeneous mass, and makes the splice impervious to moisture and the equal electrically and mechanically of the insulated wire itself.

Okonite Tape has no equal and should always be used to obtain perfect splices.

Standard stock package is ½ pound of ¾" tape, but any width and any weight roll can be furnished.

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The Standard for Friction Tape

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Manson Tape is strongly adhesive, does not unwrap, and does not corrode copper wire.

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The railroad executive knows that his office employees can work efficiently only when they are under a lighting system that gives plenty of light of the RIGHT QUALITY.

And when we say "right quality" we mean well diffused, causing comparatively little shadow and coming from a source that is of low brightness. It is easy to get plenty of light, all that is necessary is to install large lamps, but the glare from these large lamps are terrific, and although there is a great deal of light, the working conditions are unsatisfactory.

The Four-in-One fixture equipped with a Mazda "C" lamp solves the problem. It gives an immense quantity of light diffusing the rays from the lamp and breaking up shadows, while the fixture itself due to the enameling on the globe, is of low brightness and causes no glare.

Ask our Lighting Division for a Four-in-One catalogue and our engineers will give you tneir suggestions for your lighting.

Central Electric Company
FOUNDED 1887
OKONITE IT NEVER DISAPPOINTS
The House of Service
DISTRIBUTING JOBBER
316-326 South Wells Street
CHICAGO

GLARE!

If you will take this page out into a few points in your shops and read it under the same light that your mechanics work by, you will, in most cases, realize what one of the main causes of wasted time, spoilage and accidents is—inadequate light.

And when we say "inadequate light" we do not mean cheap light—in fact we are absolutely sure you are paying too much for lighting your shops, especially if you count the indirect cost.

You pay for light when an operative stops work to readjust a drop cord.

You pay for light when cloudy weather makes accurate inspection difficult or perhaps impossible.

You pay for light, often a staggering price, in the form of spoilage.

The R. L. M. Maxolite and the Maxolite Diffuser installed in your shops at the correct mounting height and spacing distances will effect big economies for you. Order a sample and let us suggest the method of installing! Then ask for bulletin No. 75 and give our engineers an opportunity to personally talk over your problems with you.

DELTABESTON WIRE
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DELTABESTON HEATER CORDS

Stranded Conductor

ASBESTOS INSULATION

CAB CORD

Deltabeston heater cord is insulated entirely with asbestos, not having the usual cotton braid over-all. Due to the fact that it contains no inflammable material, it is used widely by the railroads as drop cords in locomotive cabs, especially in connection with gauge lights. So successful has it been that it is known to many 'roads as "Deltabeston Cab Cord."

Samples will be gladly furnished on request.

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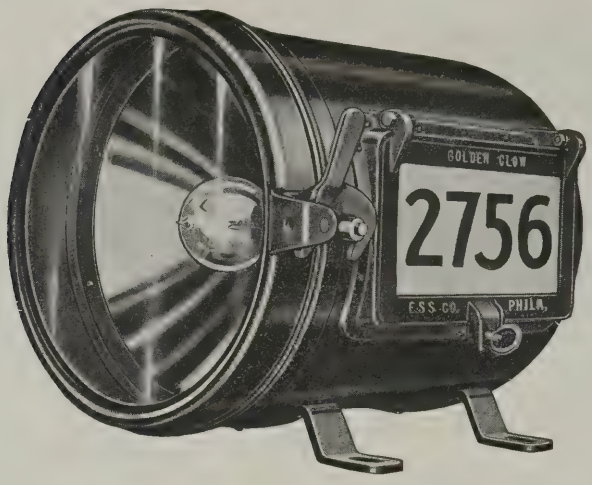
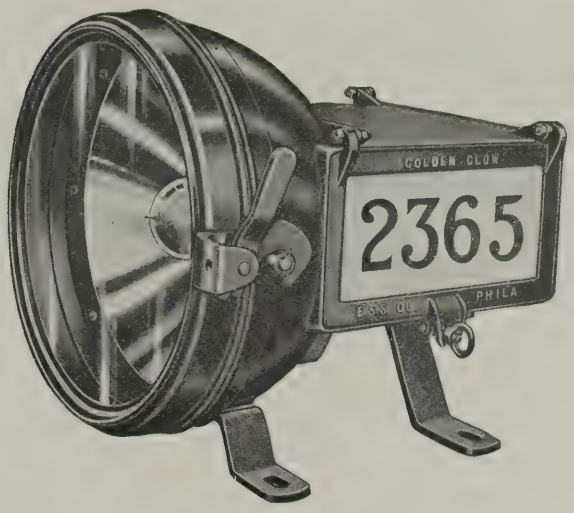


TYPE F. F. 1412 GOLDEN GLOW HEADLIGHT
(SHEET IRON CASE)

Just What Constitutes a Thoroughly Satisfactory Glass Reflector For Locomotive Headlight Service?

The application of the glass reflector to locomotive headlight service is fast becoming an accomplished fact because it is the only real step taken in years to materially improve the performance of the headlight and at the same time greatly lessen the cost of maintenance. These facts are fully recognized by the American Railroad Association and other Organizations, who have gone on Official record in support of same, as well as by leading Railroad Officials who have investigated the subject.

We as pioneers in the practical introduction of the glass reflector to the locomotive headlight field, and basing our knowledge on many years of practical experience in the broad field of headlighting together with unstinted expenditure in research work, have learned that there are great differences in glass reflectors. To be successful in locomotive headlight service glass reflectors must possess certain vital characteristics properly co-ordinated; as for example, the use of proper materials for the glass batch, the most painstaking annealing of the rough blanks, grinding and polishing under highly accurate mathematical and optical rules, and silvering properly applied and protected. And to all of the above may be added the knowledge required to build a case to properly and effectively house such a reflector. In short, satisfactory and efficient glass reflectors cannot possibly be chosen by their general appearance or by a specification covering their diameter, nor can cases be chosen only as such.



TYPE F. C. 1412 GOLDEN GLOW HEADLIGHT
(CAST IRON CASE)

As the leading Manufacturer of headlights embodying glass reflectors, used in nearly 70,000 installations on electric railway cars, steam and electric locomotives, etc., we are constantly bending our efforts to prevent the use of cheap and improperly made glass reflectors that by their poor and inefficient performance cannot help but retard and restrict the use of efficient glass reflectors in the field of locomotive headlighting and so deny to Railroads the manifold advantages to be obtained from same.

A glass reflector can be no better than the experience and facilities of the Manufacturer producing same. As the undisputed pioneers in the development, perfection and introduction of highly efficient and long lived glass reflectors, available at a reasonable price, we offer our famous "GOLDEN GLOW" reflector as the most accurate, efficient and durable glass reflector obtainable for locomotive headlight service.

Bulletin No. 182, on "GOLDEN GLOW" Headlights For Locomotive Service," contains a great deal of valuable information on our line of cases and reflectors, besides illustrating a number of our more important types.

We are prepared to submit samples of any of our standard types for service test without any obligation to purchase. May we have the pleasure of hearing from you on this subject?

WRITE FOR BULLETIN NO. 182

ELECTRIC SERVICE SUPPLIES CO.

Manufacturer of Railway Material and Electrical Supplies

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17th and Cambria Streets	50 Church Street	Monadnock Building

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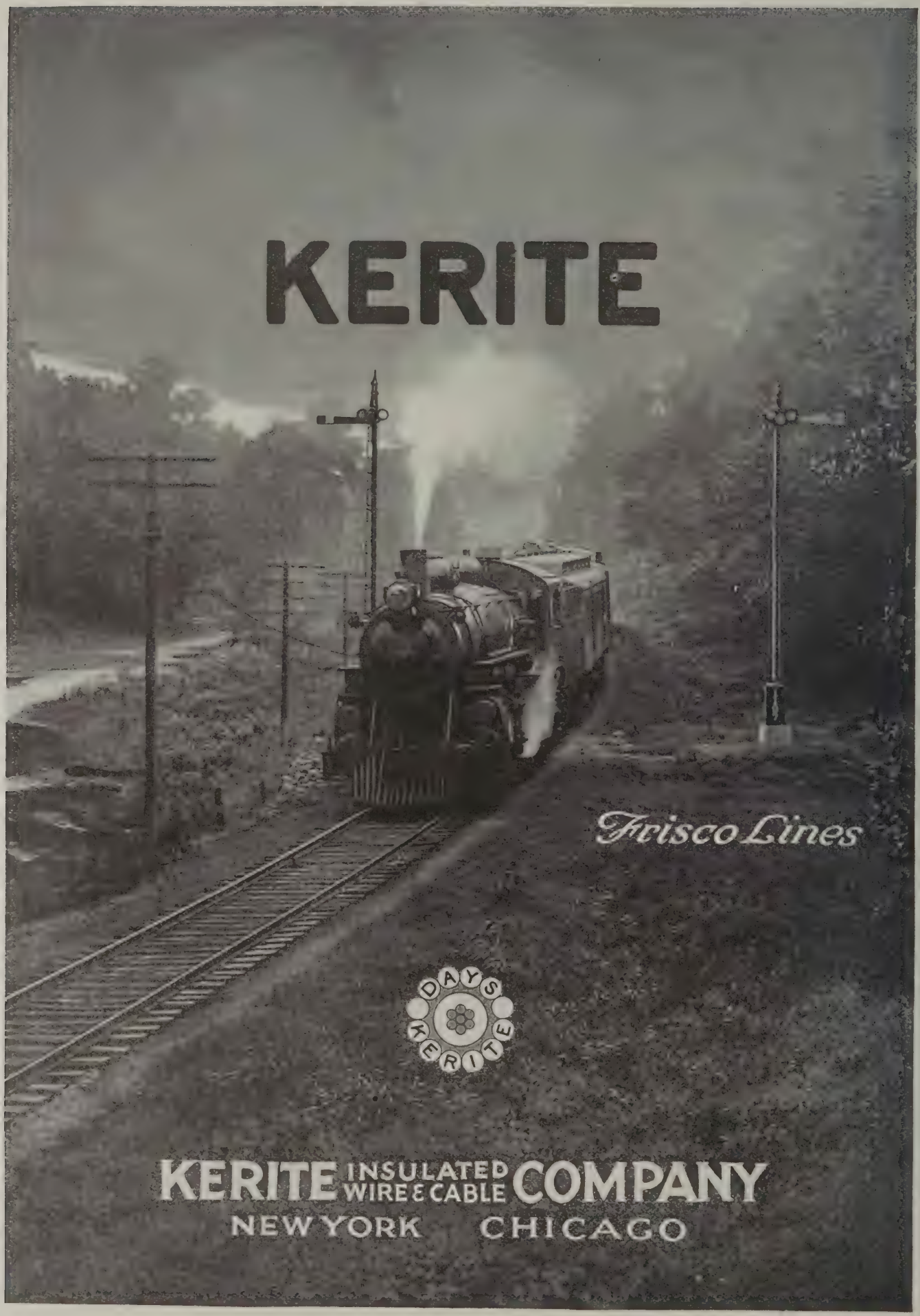
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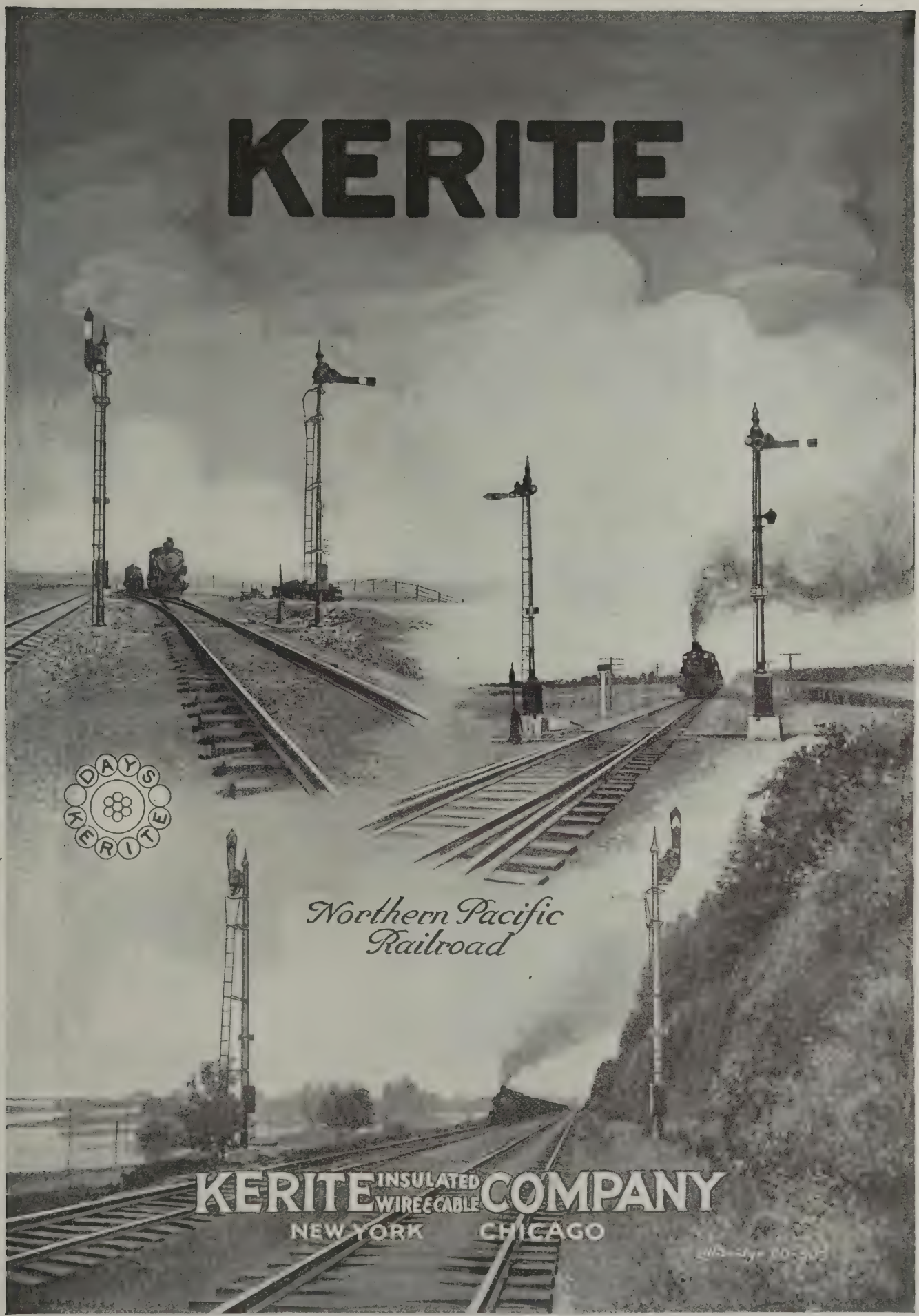
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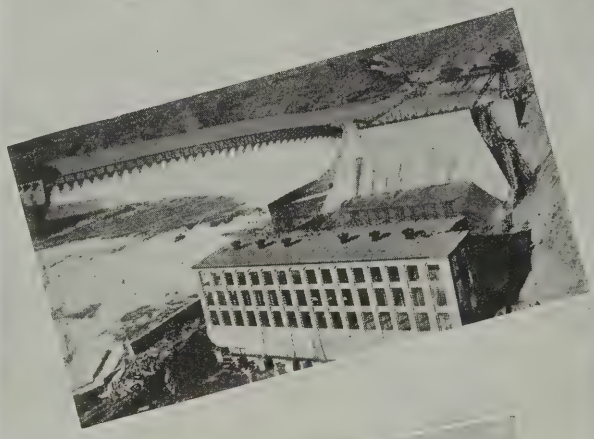
A National Product



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There is a National Product for every electrical wiring need—for Power House Installations, Erecting Shops, Machine Shops, Roundhouses, Multiple Unit Cars, Battery and Car Lighting Systems and Offices, etc.

All of them are built to the highest standards of quality, safety and service.

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The Standard for Surface Wiring.

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Rubber Covered Wire and Cables.

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Outlet Boxes and Covers, Switch Boxes, Fixture Studs, Brackets, Locknuts and Bushings, etc.

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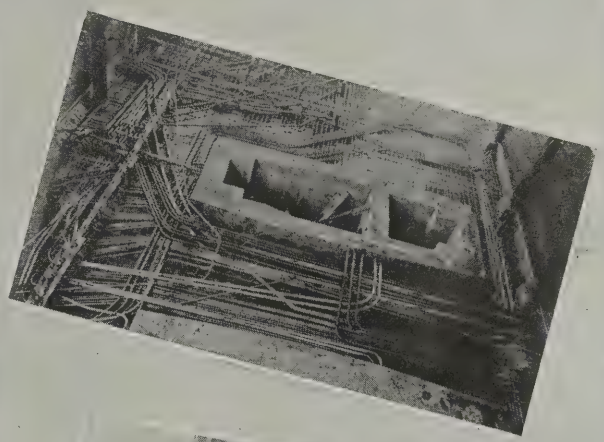
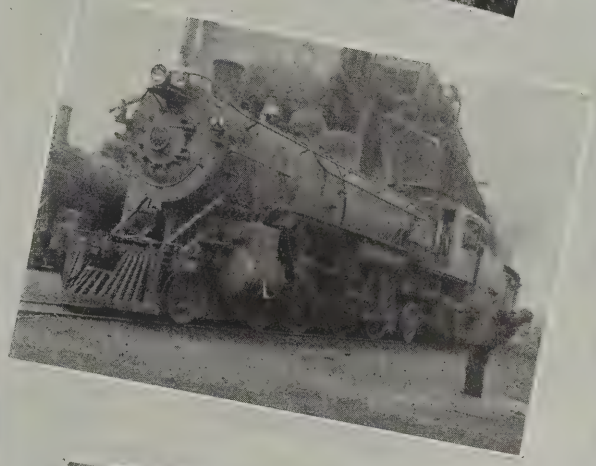
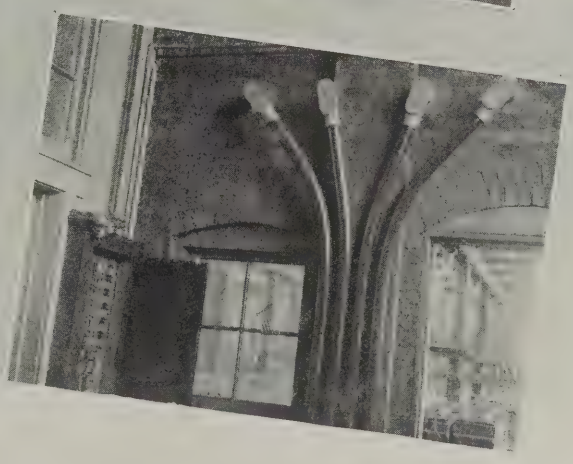
Conduit and Fittings for Automobile Wiring, Carburetor and Exhaust Tubing.







National Metal Molding Co.

Pittsburgh, Pa.

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Boston	Portland	Santiago, Chile
Chicago	Salt Lake City	Medellin, Colombia
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Detroit	Seattle	Manila
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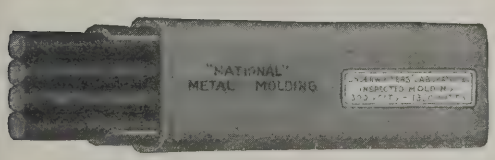


Why You Should Buy 40 Degree Motors

A so-called single rated 50 degree motor sells for less than a standard 40 degree motor.

It *should* sell for less—it has less material—and of course will give proportionately less service.

Note the pictures below. They clearly demonstrate the necessary additional material required to produce a 40 degree motor.

The feeling of safety and confidence that goes with overload capacity, lower temperatures, higher torque and better all around performance of the 40 degree motor is worth far more than you pay for it.

Fairbanks-Morse Motors Are 40 Degree Machines

COMPARE THE GUARANTEES

This is the 50 degree "continuous rated" temperature guarantee:—

Temperature rise full load continuously ..... **50°c**

No overload guarantee.

This is the Fairbanks-Morse temperature guarantee:—

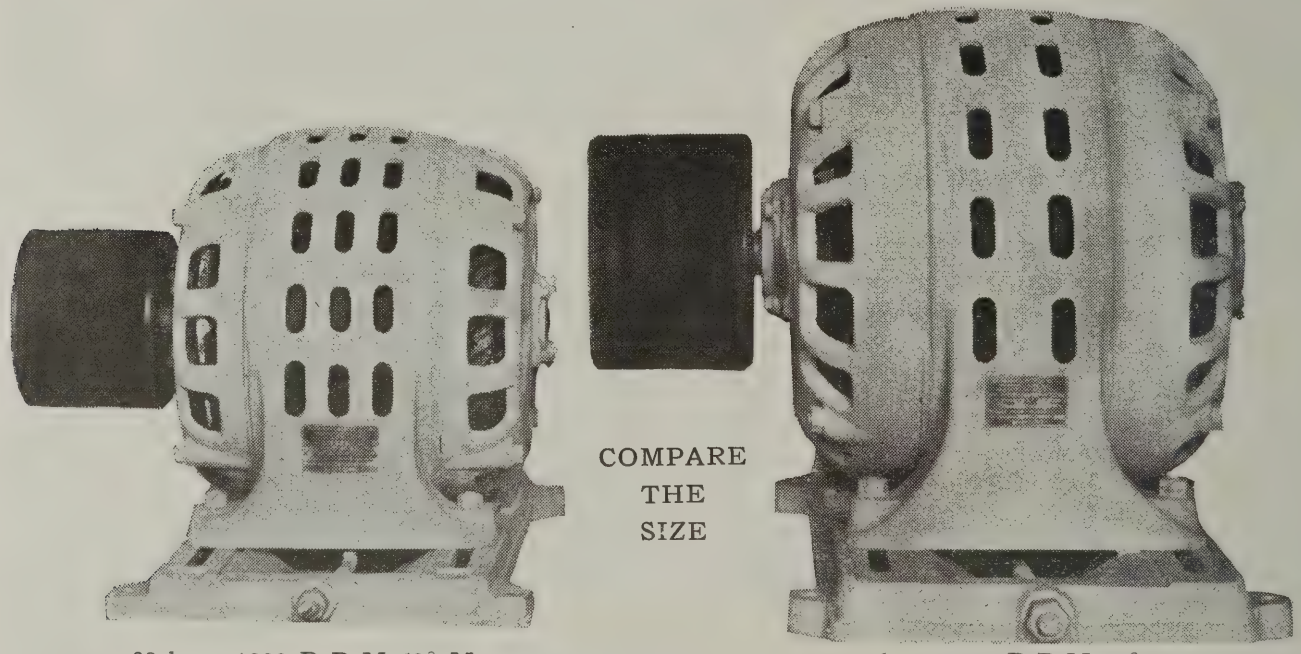
Temperature rise full load continuously ..... **40°c**

25% overload for 2 hours ..... **55°c**

COMPARE THE WEIGHT

This is the size of a motor designed to meet the 50 degree guarantee.
Net weight, 620 lbs.

This is the size of a Fairbanks-Morse 40 degree motor.
Net weight, 834 lbs.

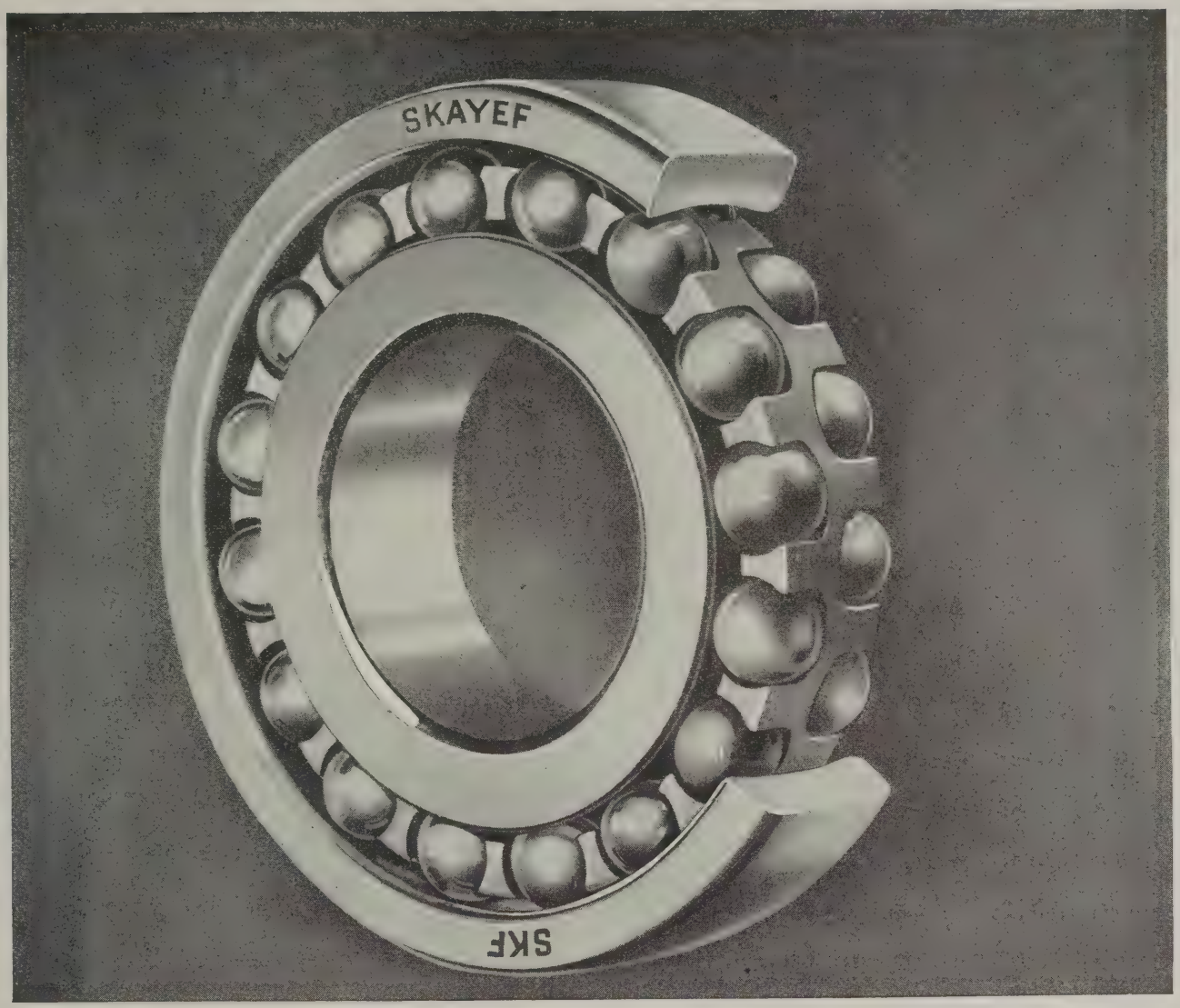


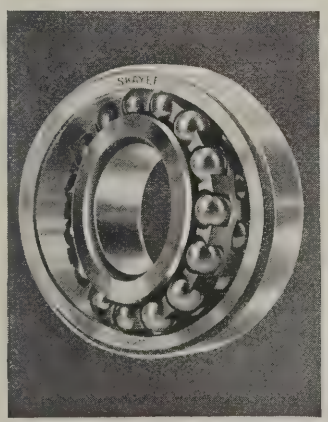
30 h. p. 1800 R P M 50° Motor.

30 h. p. 1800 R P M 40° motor.

Fairbanks, Morse & Co.
MANUFACTURERS CHICAGO

Oil Engines - Pumps - Electric Motors and Generators - Fairbanks Scales - Railway Appliances - Farm Power Machinery





The modern, highly developed, self-aligning ball bearing

is due to the world-wide studies of SKF engineers, and the experience of The Skayef Ball Bearing Co. These made possible the development of the Self-Aligning bearing, whose special function besides carrying radial loads, is to compensate for shaft misalignment.

The entire engineering experience of our organization is at your disposal. You are urged to submit your bearing problems to us for careful and impartial consideration.

The Skayef Ball Bearing Co.

Supervised at the Request of the Stockholders by

SKF Industries, Inc.

165 Broadway, New York City

624

Stone Franklin Car Lighting System

Simple - Operates without the use of carbon piles, dash pots, tension springs or crowned pulleys.

Reliable - Proved by severe suburban and fast through line service on thirty-three American railroads.

Economical- Saves at least 8% of the first cost of the battery. When the battery is fully charged the generator is disconnected. Only when the generator operates below minimum full load speed is the battery used for lighting.

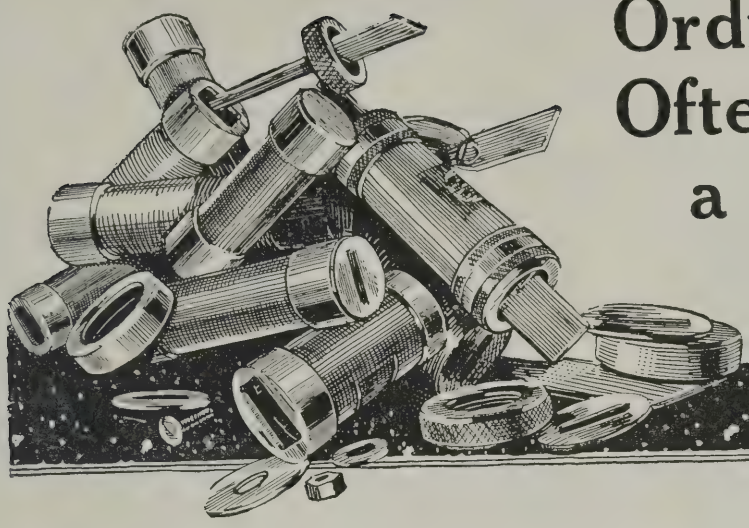
Before Specifying Your Car Lighting System Investigate the Service Records of the Stone Franklin Equipment.

STONE FRANKLIN COMPANY

17 East 42nd St.
New York

6400 Plymouth Ave.
St. Louis, Mo.

Transportation Bldg.
Montreal



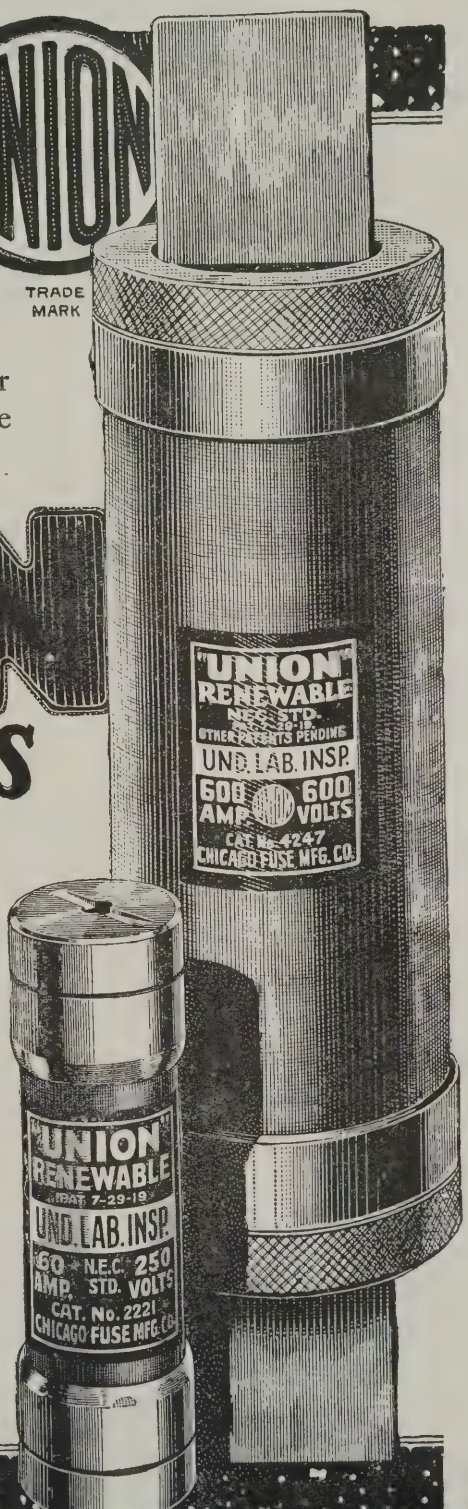
Ordinary Fuses Are Often Scrapped After a Blow-out Because Hard to Renew

Bang!—and into the scrap heap it goes. That's the fate of many renewable fuses—discarded *before* their time because they are difficult to renew. The electrician simply won't bother with them.

How many of *your* fuses are scrapped in the course of a year while *still good* for a number of renewals? Such losses are stopped for all time by using easy-to-renew

"UNION" RENEWABLE FUSES

UNION TRADE MARK



Both the knife-blade and ferrule types can be quickly reloaded with a new fusible element.

The wonderful structural strength of "Union" Renewable Fuses gives them the stamina to withstand more blowouts than any other fuse.

Both the Renewable and Non-Renewable types in all capacities, both 250 and 600 volts, have the unqualified approval of the National Board of Fire Underwriters and bear their stamp, "Und. Lab. Insp."

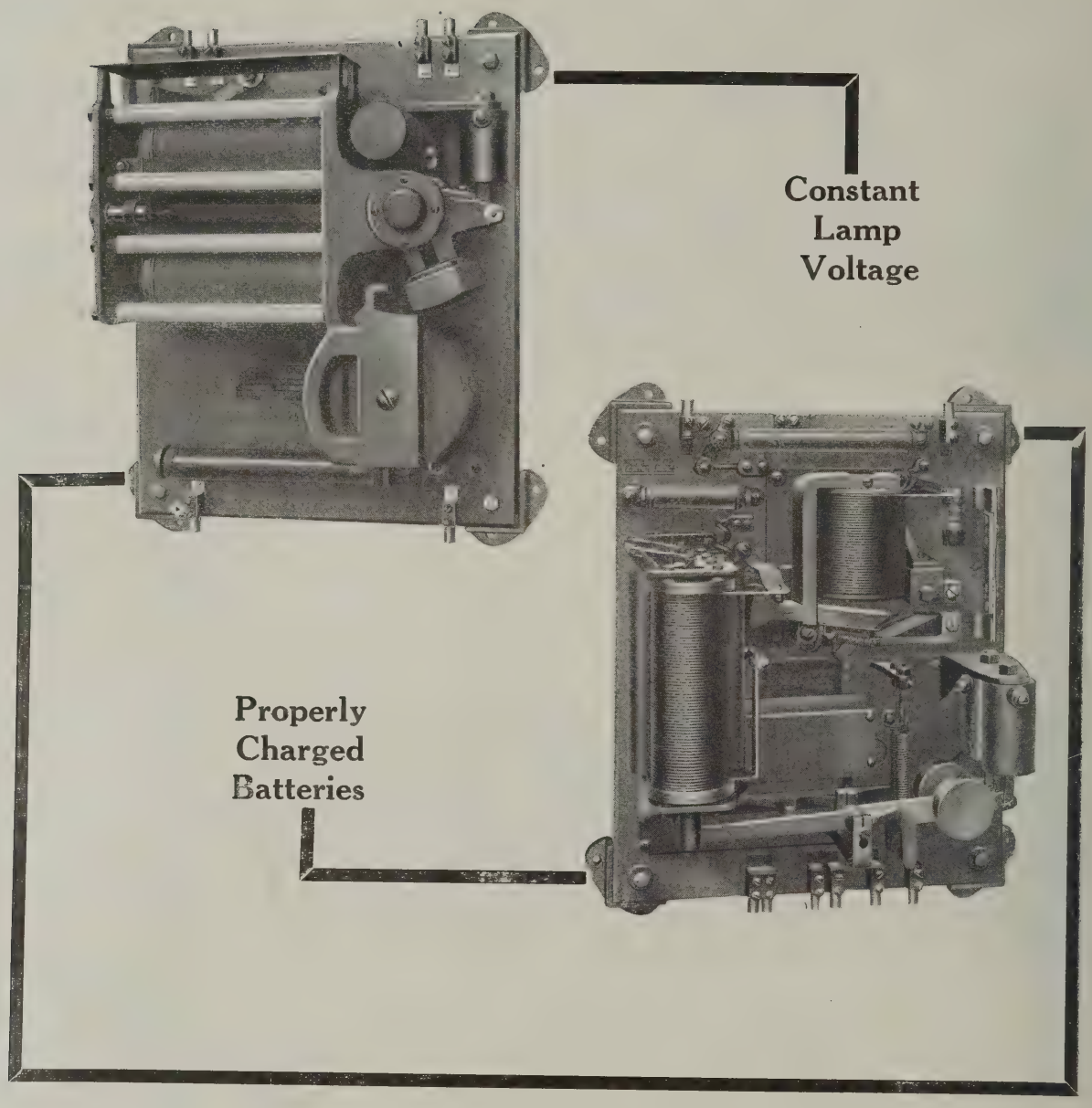
Sold by electrical jobbers and dealers everywhere. Booklet containing many important fuse facts mailed on request.

The "Union" saves more than ANY other renewable fuse.

CHICAGO FUSE MFG. CO.

Manufacturers of Switch and Outlet Boxes, Cutouts, Fuse Plugs, Automobile Fuses, Renewable and Non-Renewable Enclosed Fuses

CHICAGO **NEW YORK**



SAFETY ELECTRIC LIGHT

IS

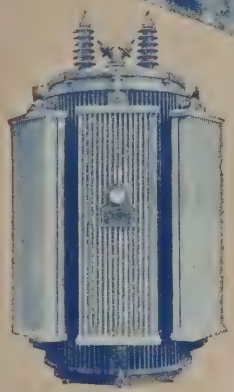
DESIGNED FOR ALL CLASSES OF
RAILWAY CAR LIGHTING SERVICE

The SAFETY CAR HEATING & LIGHTING CO.

New York Chicago St. Louis Boston Philadelphia San Francisco Montreal

The industrial use of electrical energy derived from available water power will pay big dividends on dollars invested in this development

Hydro-Electric Plant and Development — power from one of the greatest natural resources.



Oil-Cooled Transformer—one reason for the big increase in distance of carrying electricity.

Induction Type Voltage Regulator—means electric power as you want it.

Electricity—the power of progress

Accessibility of power to industry is no longer expressed in terms of "setting the mill beside the stream." Modern industry largely depends upon bringing the power of the stream to the mill, the site of which may be hundreds of miles from the source of water power supply—and electricity does it.

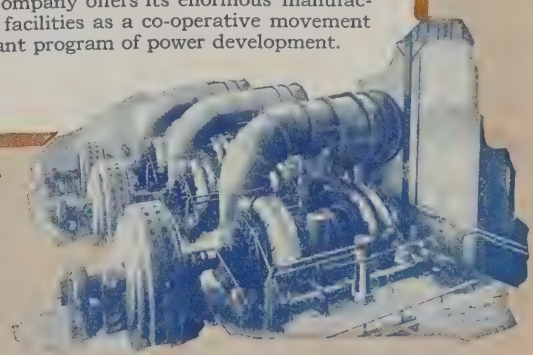
Electricity also brings the enormous resources of the country's coal mines to the public for general utility, for electrical energy amounting to billions of horsepower hours per year is efficiently and economically developed in the steam power plants of the nation.

Co-ordinated research, engineering, manufacturing and commercial efforts have made such a possibility an achievement of quick and ample power delivery at a cost which permits rapid development of industry.

The General Electric Company offers its enormous manufacturing and engineering facilities as a co-operative movement to advance this important program of power development.

43B-500

Three Phase Static Condenser Equipment—for power factor correction.



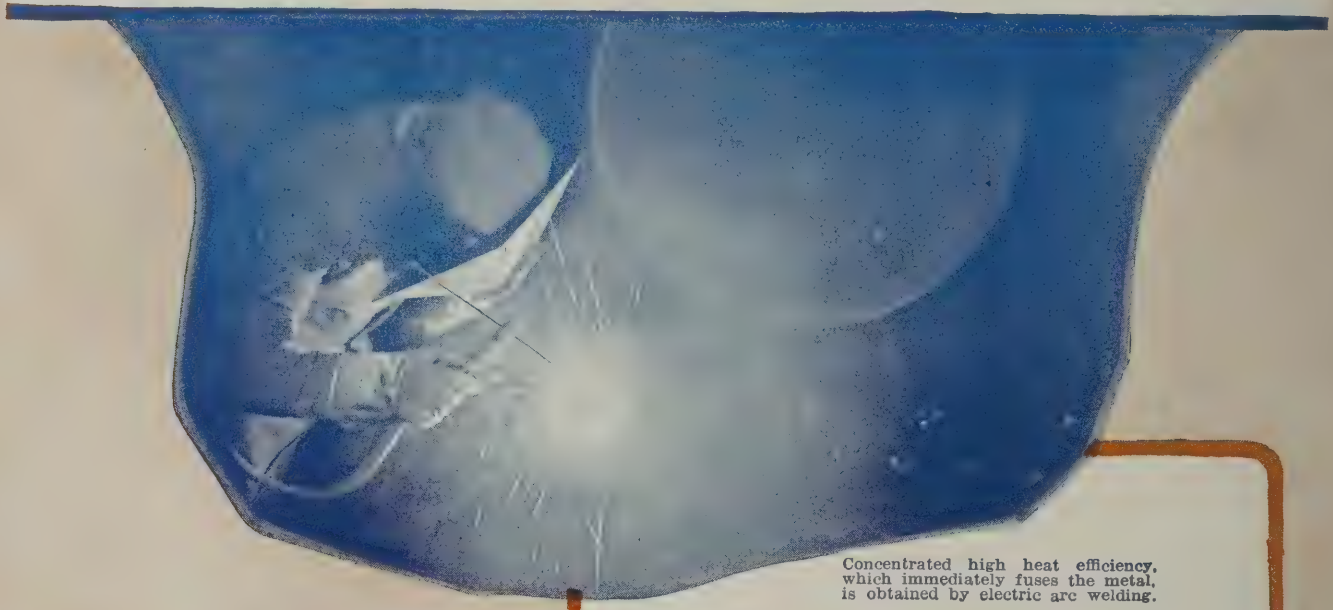
Three Water Wheel Generator Sets in Modern Power Plant.

General Electric Company

General Office Schenectady, N.Y.

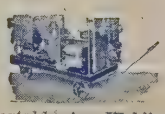
Sales Offices in all large cities

Progressive industry quickly gives preference to the process which can show its advantages over other methods—the modern way is to do it electrically

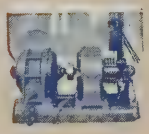


Concentrated high heat efficiency, which immediately fuses the metal, is obtained by electric arc welding.

Tilting Type Electric Brass Melting Furnace—2250 lbs. per hour



Portable Arc Welding Set permits of maximum use



Stationary Arc Welding Set is easily installed for operation.

Self-Regulating Bench Type Electric Melting Pot for metals—Bulletin 69703

Electric Rivet heater is essential to quick work well done—Bulletin 69701

Electric Soldering Iron — Production Helps in Booklet B-3514

Utilize electric heat to the utmost

Electric industrial heating equipment is increasing production wherever it is applied. One of the most essential of electric heating methods is *electric arc welding.*

Electric arc welding maintains advantages in quantity, quality, and cost—wherever iron or steel is to be joined in repair work, salvage, or original manufacture. The utilization of its possible applications extends over steel and iron works—boiler shops—foundries—repair shops—machine shops—and innumerable other industries.

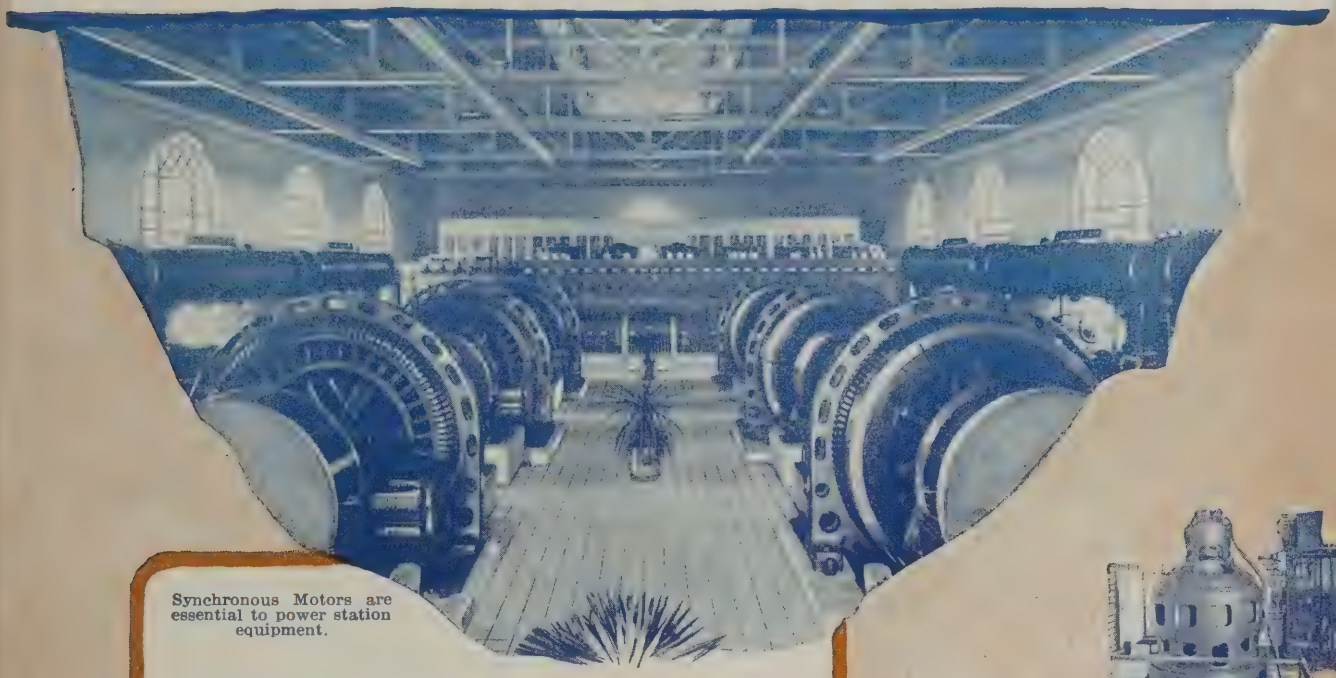
An unusual simplicity and elasticity of operation has been perfected in the designs of Stationary and Portable Arc Welding Sets manufactured by the General Electric Company. This equipment can be provided for either group or single operator service, and generator can be driven by any source of power—engine, belt, d-c. or a-c. motor. Send for Bulletin 48932-A.

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

Many users of electric power keep pace with industrial advancement by judicious application of motors which "keep step" with the current generator



Synchronous Motors are essential to power station equipment.

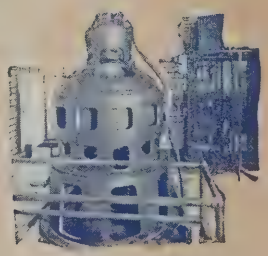
Synchronous Motors—why used and where

Realization of the benefits of synchronous motor drive to practically all classes of industry today has been established by the unexcelled performance of this equipment in thousands of applications.

The continued maximum efficiency and durable operation of the synchronous motor have demonstrated their dollar-earning and dollar-saving qualifications in Steel Plants—Automobile Factories—Railroad Shops—Paper, Rubber, Flour, Cement and other Mills—where greater and more uniform production has been obtained at lower maintenance cost.

In addition to carrying a load, the synchronous motor is an efficiency guide to the power factor of the distribution system—bolstering up the laggard that eats into profits, cuts down output, and overworks machinery.

The recognized merits of the synchronous motor tell *why* you should use it. Ask specialists of the General Electric Company *where* its application fits your particular needs. Bulletin No. 41310 gives detailed uses of synchronous motors, and will be sent on request.



Vertical Synchronous Motor on deep well pump at packing plant—2000 gallons water per minute.

Synchronous Motor direct connected to two 4-pocket grinders in paper mill.

Synchronous Motors with Direct-Connected Exciters driving triplex pumps at concentration mill of copper company.

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

The rush of daily trade makes quick and systematic handling of materials imperative at ports, freight depots and industrial plants

250-Volts Trolley Type Surface Locomotive hauls material direct from ship to warehouse.

Electricity does this most economically

The numerous applications of electricity to operating locomotives, conveyors, winches, stacking machines, cranes, hoists, tractors, and other mechanical devices—all have the same quick clearance effect on heavy traffic of the world's supplies at terminals.

Barrels, boxes, crates, bales, rolls—by the ton—all moving about in every direction. No collisions, no accidents, no damage of goods—for electricity keeps everything moving quickly and orderly.

The savings range all the way from a seventeen day reduction in the round trip time of an ocean liner, to the marked economy of electrically piling from thirty to fifty feet high—a thousand pounds of material per minute.

Your individual needs of material handling equipment can best be filled by the manufacturers, who in solving your problems, obtain the specialized electrical experience and products of the General Electric Company.

Electric Portable Conveyor speeds unloading with 100 ft. carry from slip to wharf shed.

Electric Portable Stacker piles 1000 lbs. per minute up to 50 ft. high.

Tractor and Trailers make quick headway in moving materials.

Portable Dock Winch—electric motor-driven—quickly puts power where you want it.

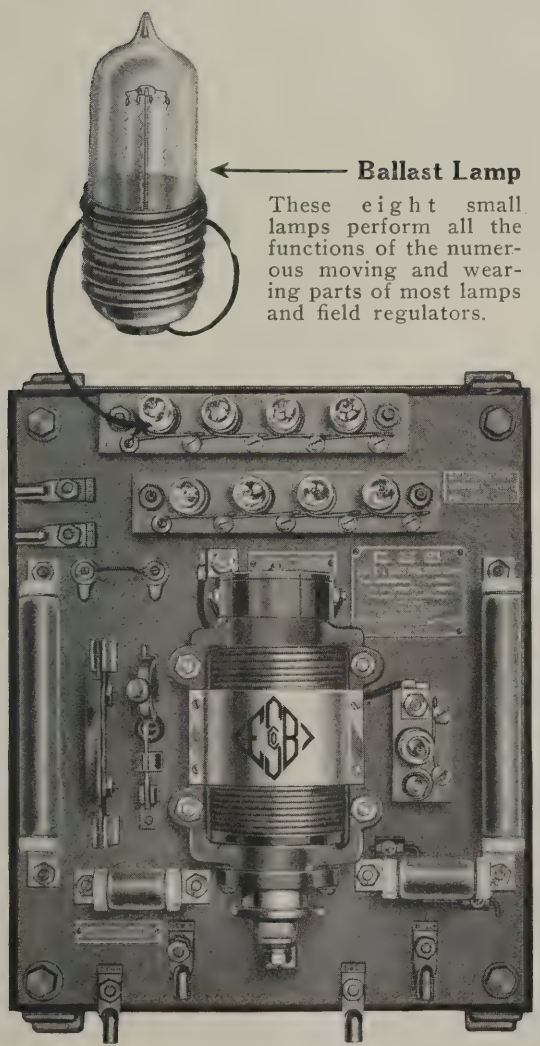
General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

Exide
BATTERIES

Always Ready for Any Change of Schedule


Ballast Lamp
These eight small lamps perform all the functions of the numerous moving and wearing parts of most lamps and field regulators.

Control Panel
The entire regulating apparatus of an E. S. B. Car Lighting Equipment.

You can't take an E. S. B. Axle Lighting System unawares.

Change it from a suburban to a transcontinental run. Bring it in from a local and send it out again on express schedule. Put it in any kind of service and it is immediately ready for duty without re-adjustment.

As a matter of fact, there's nothing on an E. S. B. System to adjust. The generator output is automatically regulated for every change of load condition by the constant voltage control.

This simplicity also eliminates pole changers, lamp regulators, carbon piles and dash pots.

In numerous other ways E. S. B. Systems are making the work of car lighting departments easier while reducing costs to a *very noticeable* degree.

If you haven't received your copy of the new bulletin on car lighting, send us your name.

THE ELECTRIC STORAGE BATTERY CO.
Oldest and largest manufacturers in the world of Storage Batteries for every purpose.

1888 PHILADELPHIA 1921

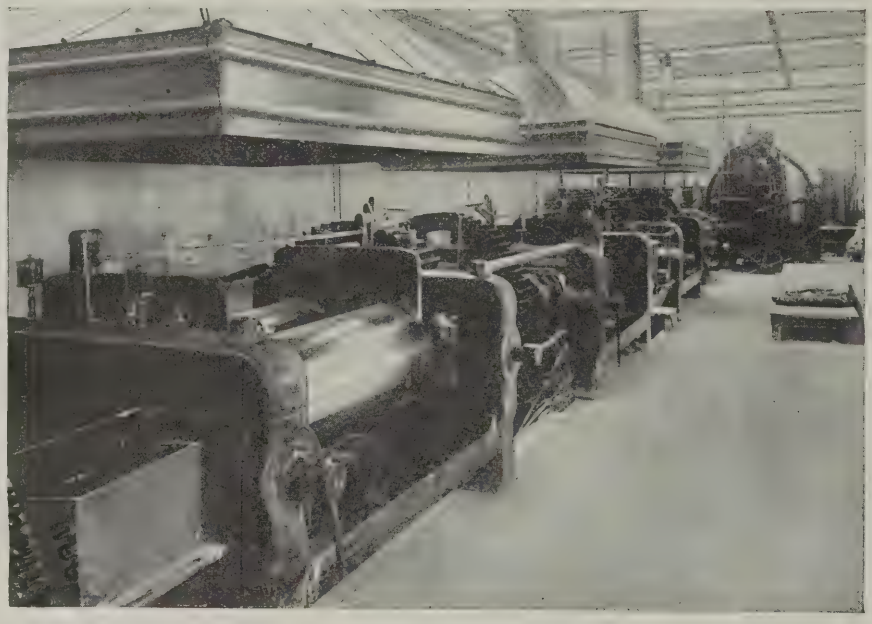
Branches in seventeen cities

Exide Batteries of Canada, Limited 133-157 Dufferin Street, Toronto

"The Story of Okonite"—4

OKONITE
TRADE MARK.

Mixing and Calendering



Jumbo Grinders in Mixing Room

Calendering Compound on Tin

In order to produce perfect insulation, care must be used in mixing or compounding. The Okonite compound is thoroughly and carefully ground and mixed and then laid aside for several days to season.

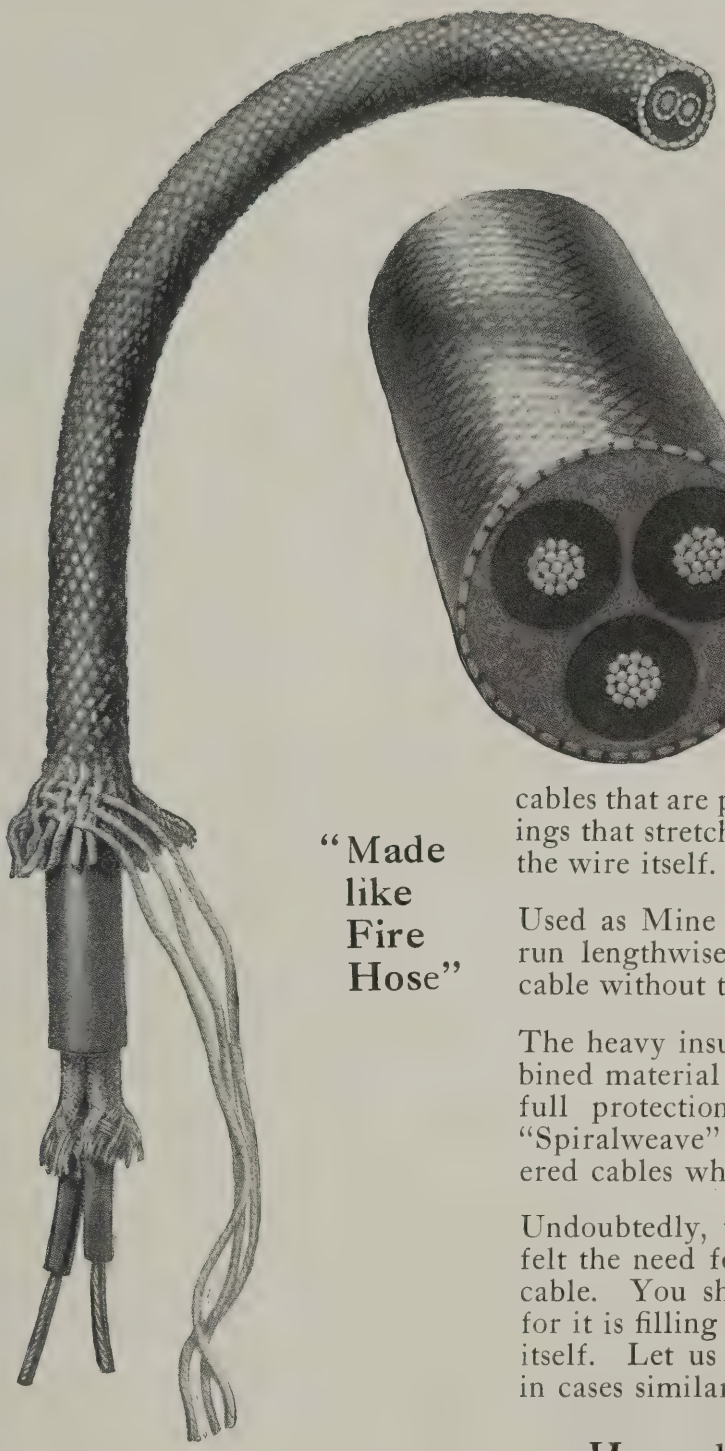
After seasoning it is warmed and calendered to the required thickness on heavy sheet tin.

Okonite Insulating and Manson Friction Tapes

THE OKONITE COMPANY, Passaic, New Jersey
Incorporated 1884

CENTRAL ELECTRIC CO., Chicago, Ill., General Western Agents

F. D. Lawrence Electric Co., Cincinnati, O. Novelty Electric Co., Philadelphia, Pa. Pettingell-Andrews Co., Boston, Mass.
The Okonite Company, Atlanta, Ga.



"Spiralweave" Cables

for Light and Power

"Made like Fire Hose"

"Spiralweave" Cables are self-sufficient. The particular method of weaving the outside covering overcomes all tendency of the cable to stretch and bulge as it is pulled and doubled about. The threads lie so as to directly counteract all pulls and surface abrasion.

Used as small Portable Cables for power and light around shops, they outwear cables that are protected only with loosely woven coverings that stretch and throw the burden of the pull onto the wire itself.

Used as Mine Shaft Signal Cables, the warp threads run lengthwise of the wire and directly support the cable without the use of steel supporting wires.

The heavy insulation, of carefully prepared and combined material and proper rubber vulcanization, gives full protection against moisture or sulphur water. "Spiralweave" can often be used in place of lead covered cables where there is danger of electrolysis.

Undoubtedly, there are many places where you have felt the need for an unusually durable power or light cable. You should surely investigate "Spiralweave," for it is filling just such needs in a way that speaks for itself. Let us tell you about the service it has given in cases similar to yours.

Hazard Manufacturing Company

New York 533 Canal St. | Pittsburgh 2213 First Nat'l Bank | Chicago 552 W. Adams St.

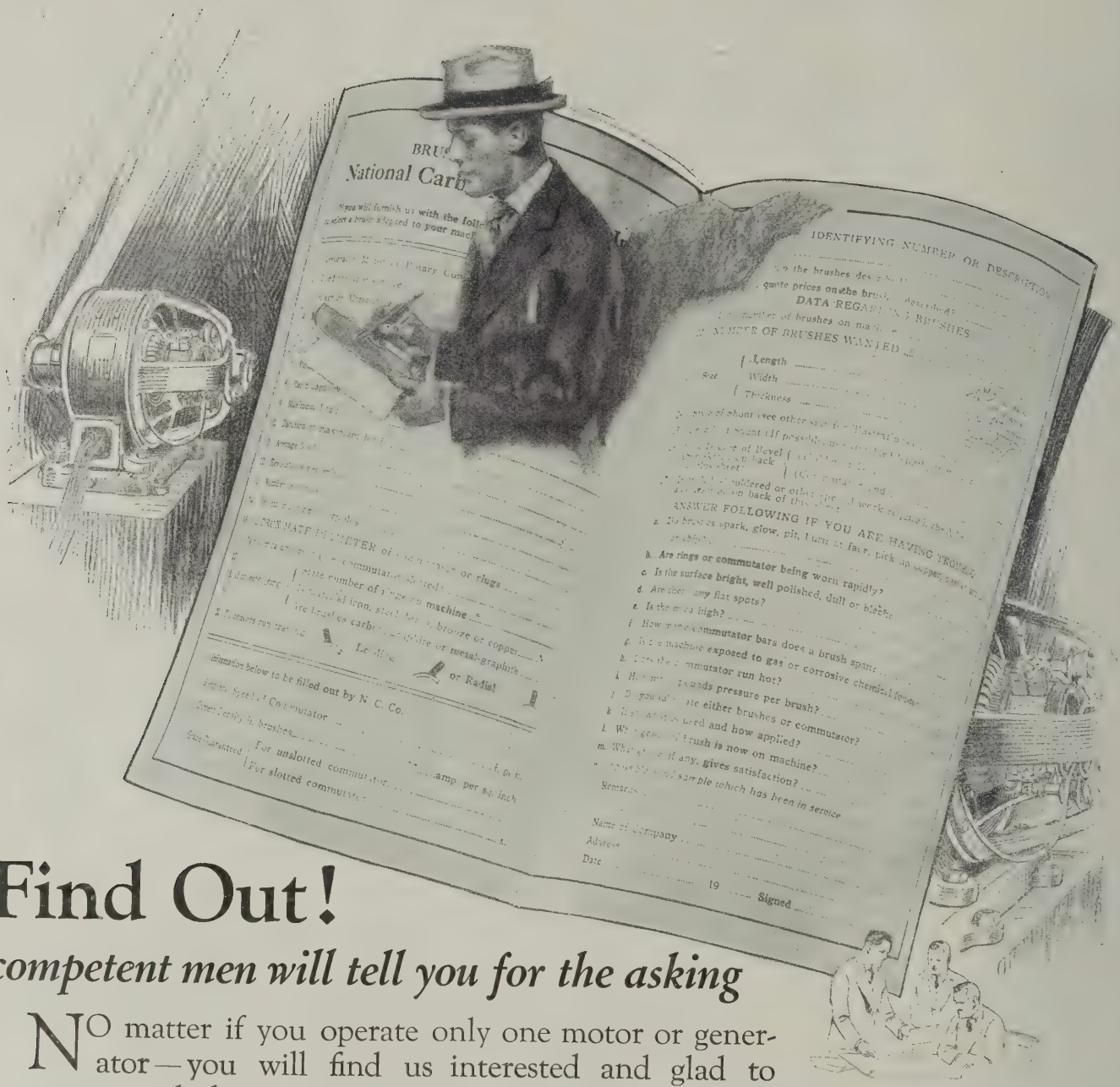
Denver 1415 Wazee St. | Birmingham 1701 First Ave.

Wilkes-Barre, Pa.

Makers of Quality Wire Rope since 1848

HAZARD RUBBER INSULATED **Wires & Cables**

1812 1921



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competent men will tell you for the asking

NO matter if you operate only one motor or generator—you will find us interested and glad to recommend the exact grade of brush required by its design and your specific work.

National Carbon Data Sheet Service solves your brush problems. Write us today

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Send in this coupon today. It does not obligate you in any way

NATIONAL CARBON COMPANY, INC.
CLEVELAND, OHIO

I wish your recommendation, which you advertise to be free of charge, as to the best grade of brushes to meet working conditions here. Please send one of your Data Sheet Blanks for each machine. I will fill it out and return it to you.

Firm_____

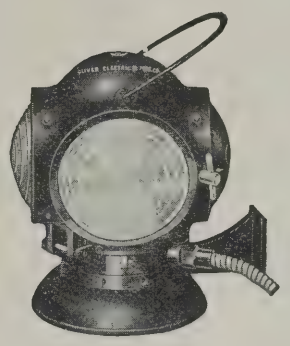
No. and Street_____

Town_____ State_____

We operate____ generators; ____ motors; ____ rotary converters
(How many?) (How many?) (How many?)

Signed by_____

Cast Aluminum Electric Classification and Marker Lamps



Electric Weatherproof lamps of non-corrosive cast metal substantially constructed, and easily wired. Built to withstand the rough usage incidental to Railroad service.

All types are furnished with mounting bracket to fit the socket now used for oil lamps.

The lamps revolve in the brackets so they can be placed at any angle desired eliminating the necessity of right and left lamps.

The Classification lamp has a throw over device inside the housing, arranged with green color screen which is operated by a handle on the outside to give the color desired.

It is not necessary to open the lamp to change the colors.

The Marker lamp has one red and three green semaphore lenses.

The color change is obtained by revolving the lamp in the bracket.

The housing on all types of lamps is standard so that classification lamps can be converted into Marker lamps and vice versa.

Lamps can be furnished with lenses of any standard color.

Write for Bulletin

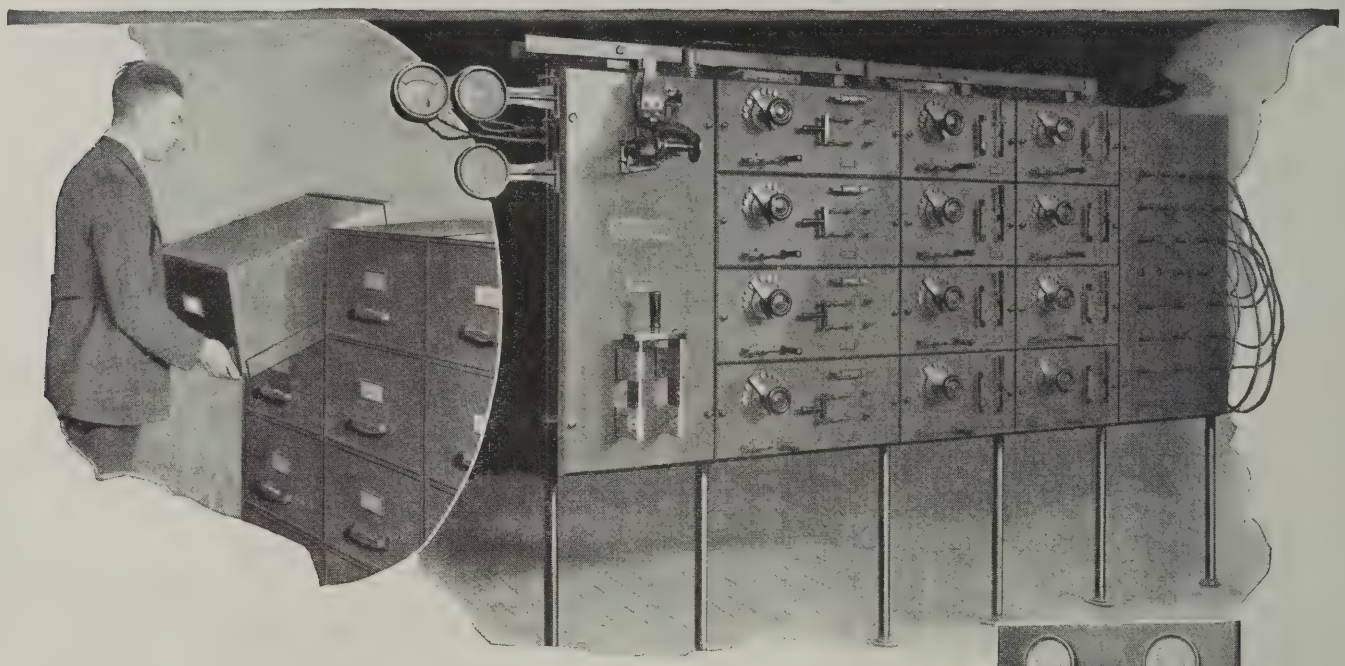
OLIVER ELECTRIC & MANUFACTURING COMPANY

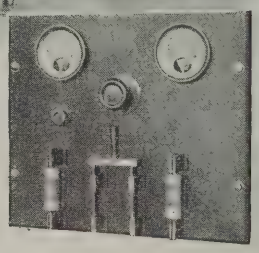
ST. LOUIS, U. S. A.

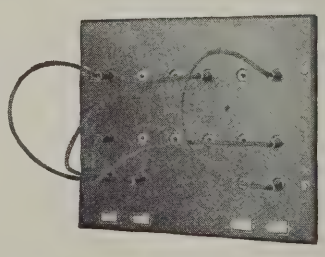
WESTERN ELECTRIC COMPANY, DISTRIBUTORS

Offices in All Principal Cities

Standard unit battery charging switchboards that can be enlarged as the need arises are the choice of far-seeing railroad electrical engineers







These G-E Switchboards Build-up Like Filing Cabinets

YOU buy filing cabinets by units and add new ones as the old sections become overloaded. G-E Standard Unit Battery Charging Switchboards for charging train lighting, baggage and mail truck batteries, are as flexible as filing cases. When the board in service is overtaxed new panels can be added without disturbing the original installation to any degree.

G-E Switchboards are backed by over a quarter century of experience in design and construction. The Company offers you a product which represents the last word in distribution apparatus.

The nearest G-E office will gladly give you further details.

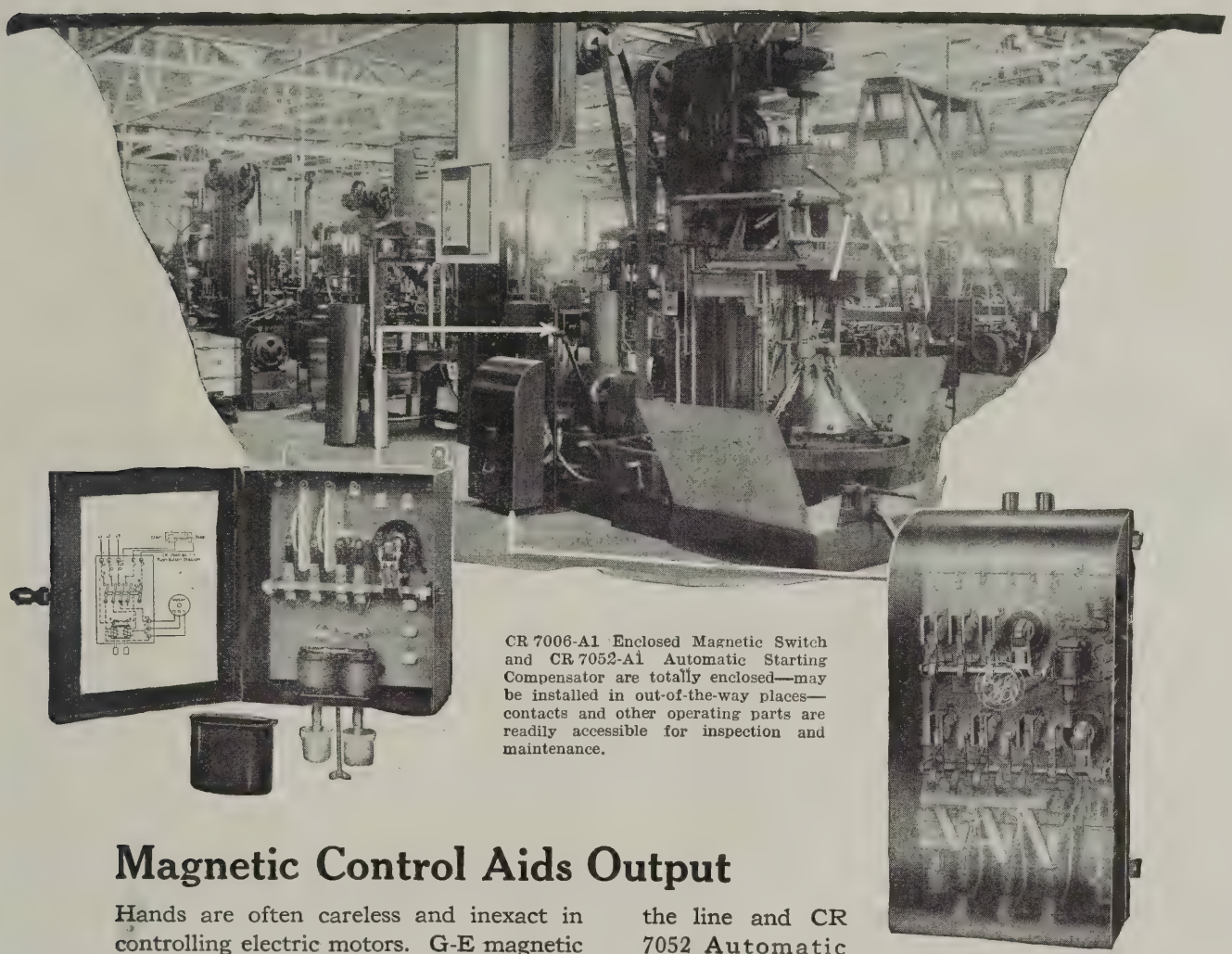
General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

28-35

Definite control and full protection over every motor in a machine shop guard against breaks in production



CR 7006-A1 Enclosed Magnetic Switch and CR 7052-A1 Automatic Starting Compensator are totally enclosed—may be installed in out-of-the-way places—contacts and other operating parts are readily accessible for inspection and maintenance.

Magnetic Control Aids Output

Hands are often careless and inexact in controlling electric motors. G-E magnetic control does it reliably—not only protecting motors against overload and under voltage, but also giving security to operators. It is the sort of control that keeps machines on the job every minute.

Thousands of CR 7006 Enclosed Magnetic Switches for starting small alternating current motors by throwing them directly on the line and CR 7052 Automatic Starting Compensators for squirrel cage induction motors are in successful use—meeting severest service in many installations.

With these substantial, easily-installed controllers, machines can be started and stopped by convenient push buttons, or automatically operated by float switches or pressure governors.

Ask our nearest office for complete information

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

48A-46

A reliable pulley for car lighting

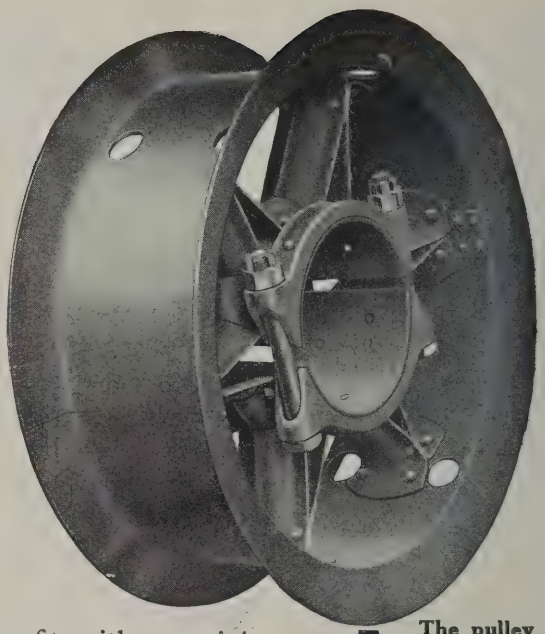
Car axle lighting pulleys must run in sand and mud in summer, in ice, slush and snow in winter. They must withstand jolts and jars of rough road beds at all seasons.

To give satisfactory service under these severe conditions requires an exceptionally strong pulley and a bushing that will positively prevent it from slipping on the axle.

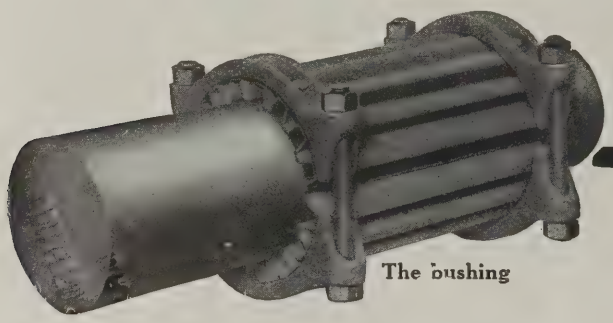
The Keystone car lighting pulley with Oneida corrugated bushing

The combination of Keystone steel pulley and Oneida corrugated steel bushing is standard with many of the best car builders in America.

The design of the pulley and the materials from which it is made insure maximum strength and endurance.



The pulley



The bushing

The bushing fits either straight or tapered axles. It grips the axle firmly under all conditions.

Write us for full information regarding this practical combination.

Dodge Sales and Engineering Co.,
Oneida, N. Y., U. S. A.
Distributor of the Products of Dodge Mfg. Co. and Dodge Steel Pulley Corporation
Originators of Steel Railroad Pulleys and Steel Corrugated Bushings

Handy Books for Electrical Engineers

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS—F. E. Fowle

A handbook written for engineers in practice by over sixty of the leading engineers in the field. There are twenty-five sections covering the following subjects: units and tables, electric and magnetic circuits, measurements and measuring apparatus, properties of materials, magnets, induction coils, condensers, transformers and rectifiers, alternating and direct current generators and motors, convertors, power plants, power transmission, distribution system, interior wiring, illumination, industrial motor applications, electric railways, vehicles and ships, electrochemistry, batteries, telephony, telegraphy and radio telegraphy, miscellaneous application of electricity. 2,000 pages, flexible binding. **$6.00**

ELECTRICAL ENGINEER'S POCKETBOOK—H. A. Foster

A handbook of useful data for electrical engineers and electricians. After giving the symbols and measurements used it takes up the subjects of electro-magnets, properties, relations and dimensions of conductors, underground conduit construction, cable testing, dynamos and motors, static transformers, illuminating engineering, arc lighting, incandescent lighting, electric street railways, electrolysis, meters, storage batteries and many other closely related subjects. 1,636 pages, 1,128 illustrations, 718 tables, full leather. **$5.00**

HANDBOOK FOR ELECTRICAL ENGINEERS—H. Pender

Combines the essential features of a library of electrical books. Clear style and convenient arrangement makes it suitable for those studying electricity and for practical electrical engineers. 2,023 pages, flexible "Fabrikoid" binding **$7.00**

ELECTRIC TRACTION FOR RAILWAY TRAINS—E. P. Burch

Designed to show the remarkable development of electric traction for railway trains during the years just preceding 1911. The subject is treated in general from the viewpoint of a steam railroad engineer who desires to study electric motive power. 583 pages, fully illustrated. **$6.00**

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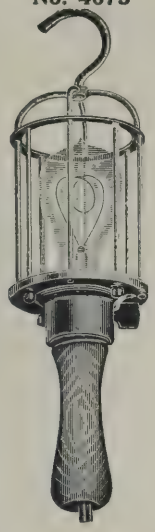

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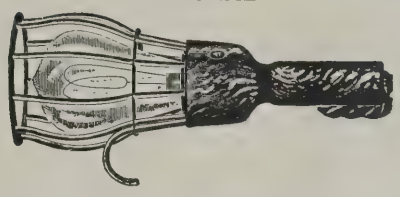

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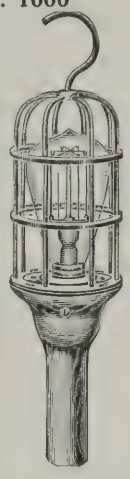

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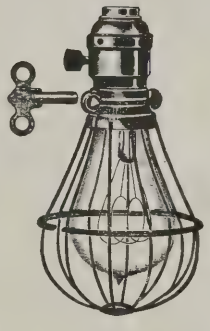

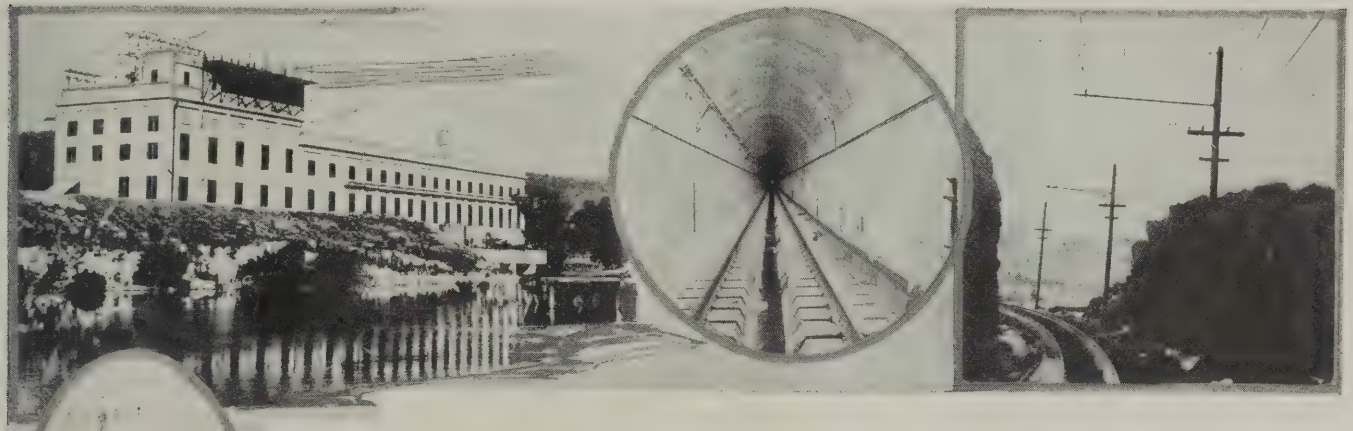

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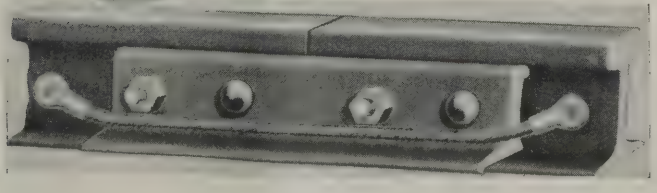

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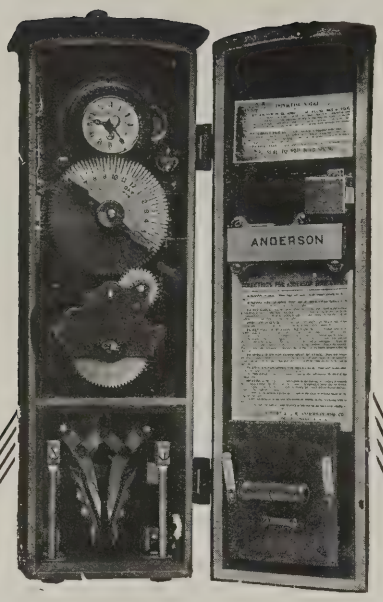

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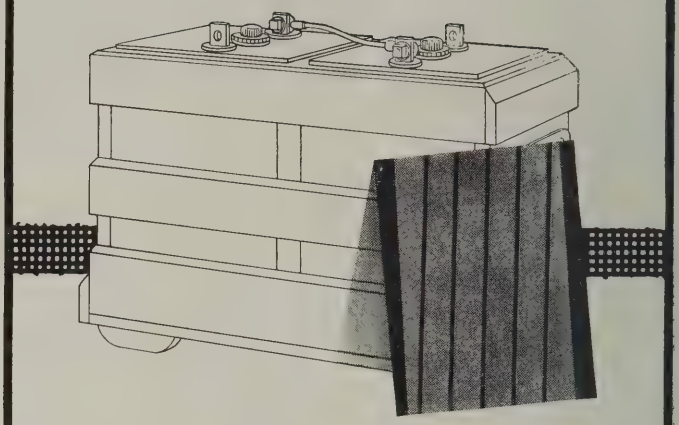

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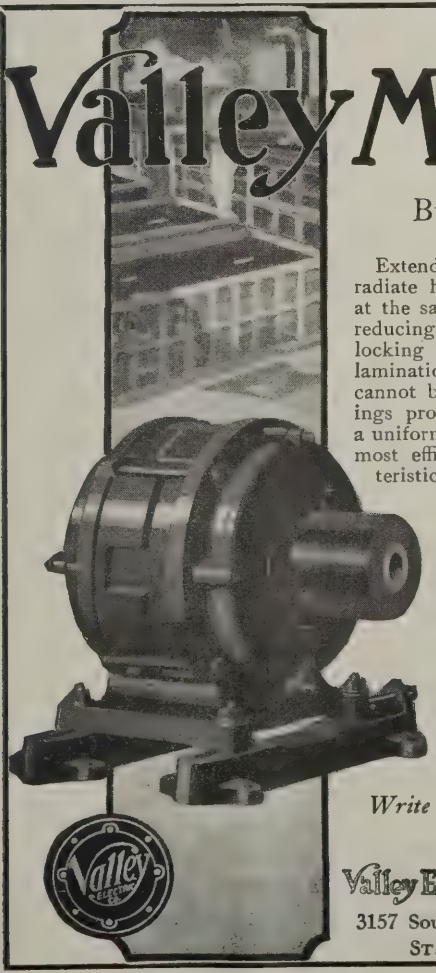

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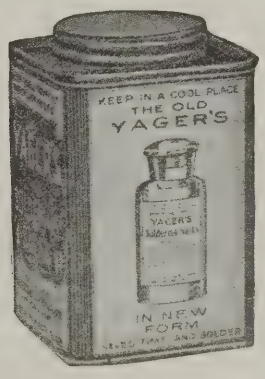

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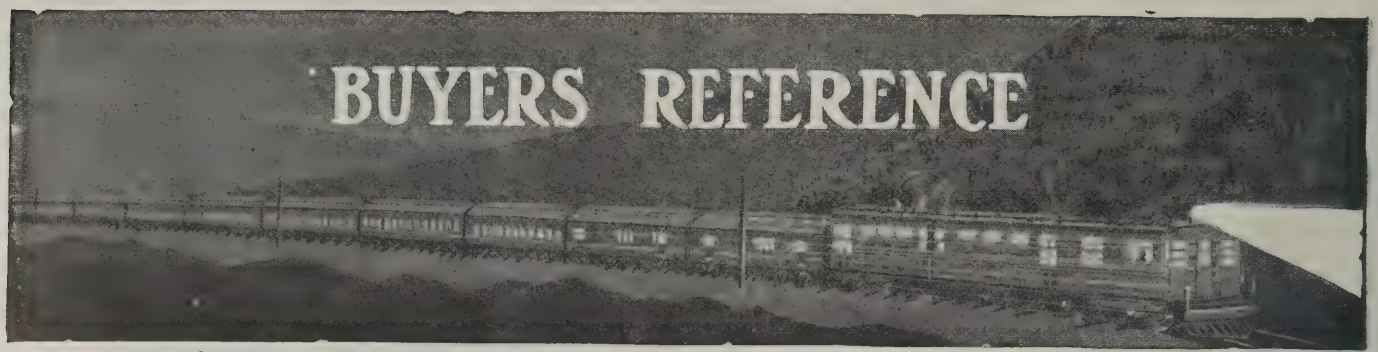

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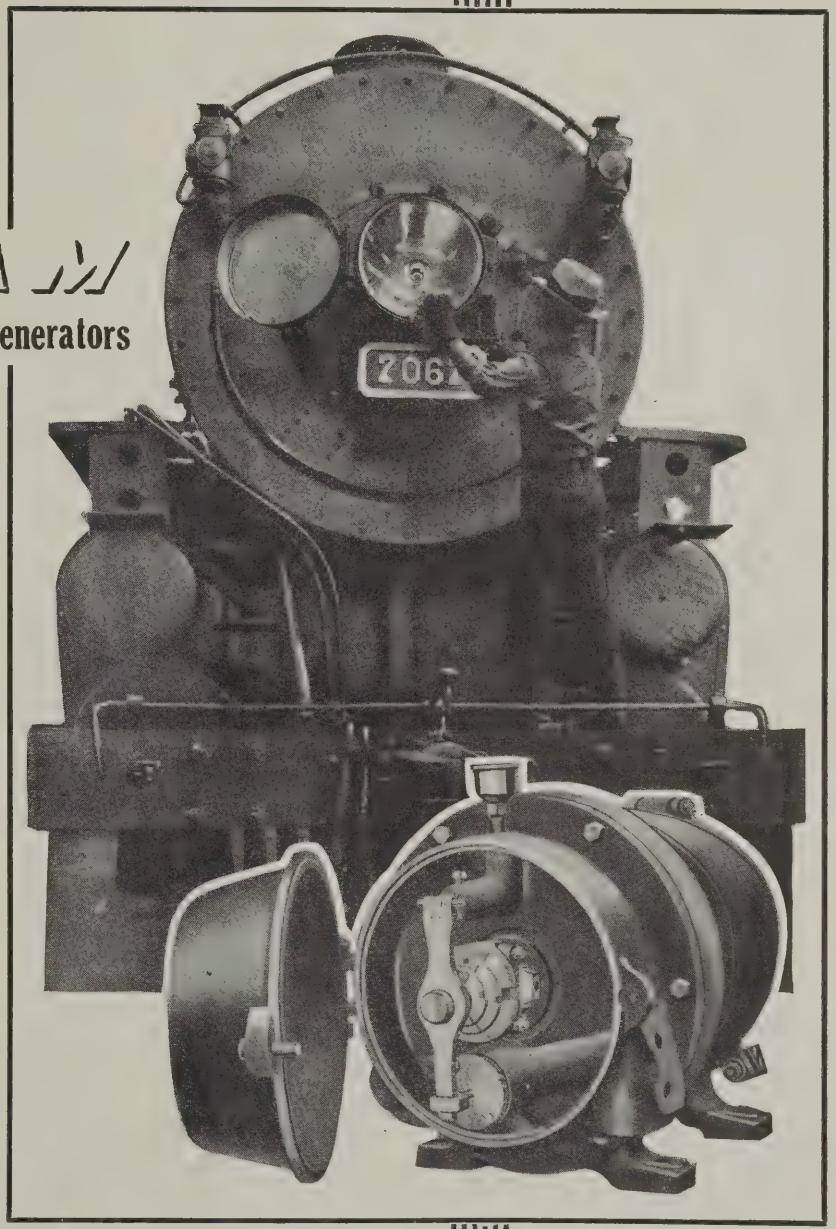

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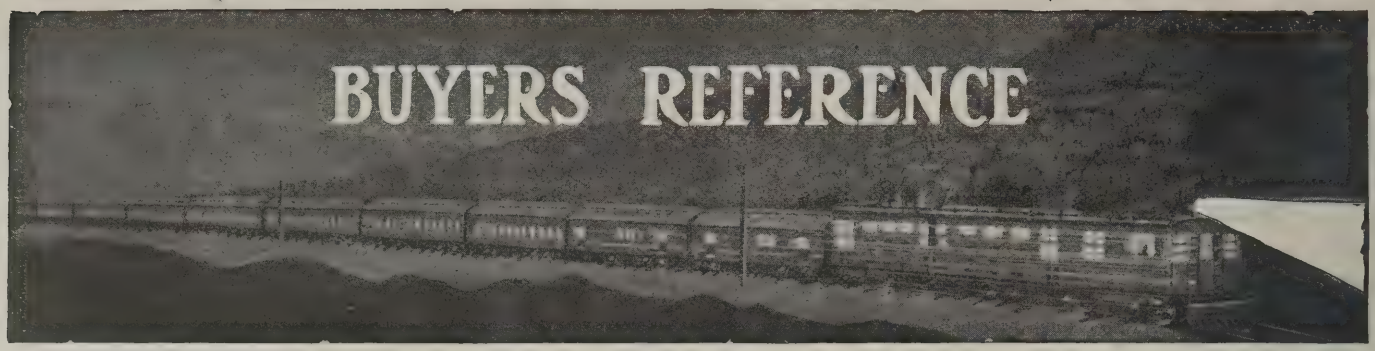

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Machine Shop records show that good lighting increases production from 10 to 15%, the increased production of better quality making good light actually cost less than poor light.

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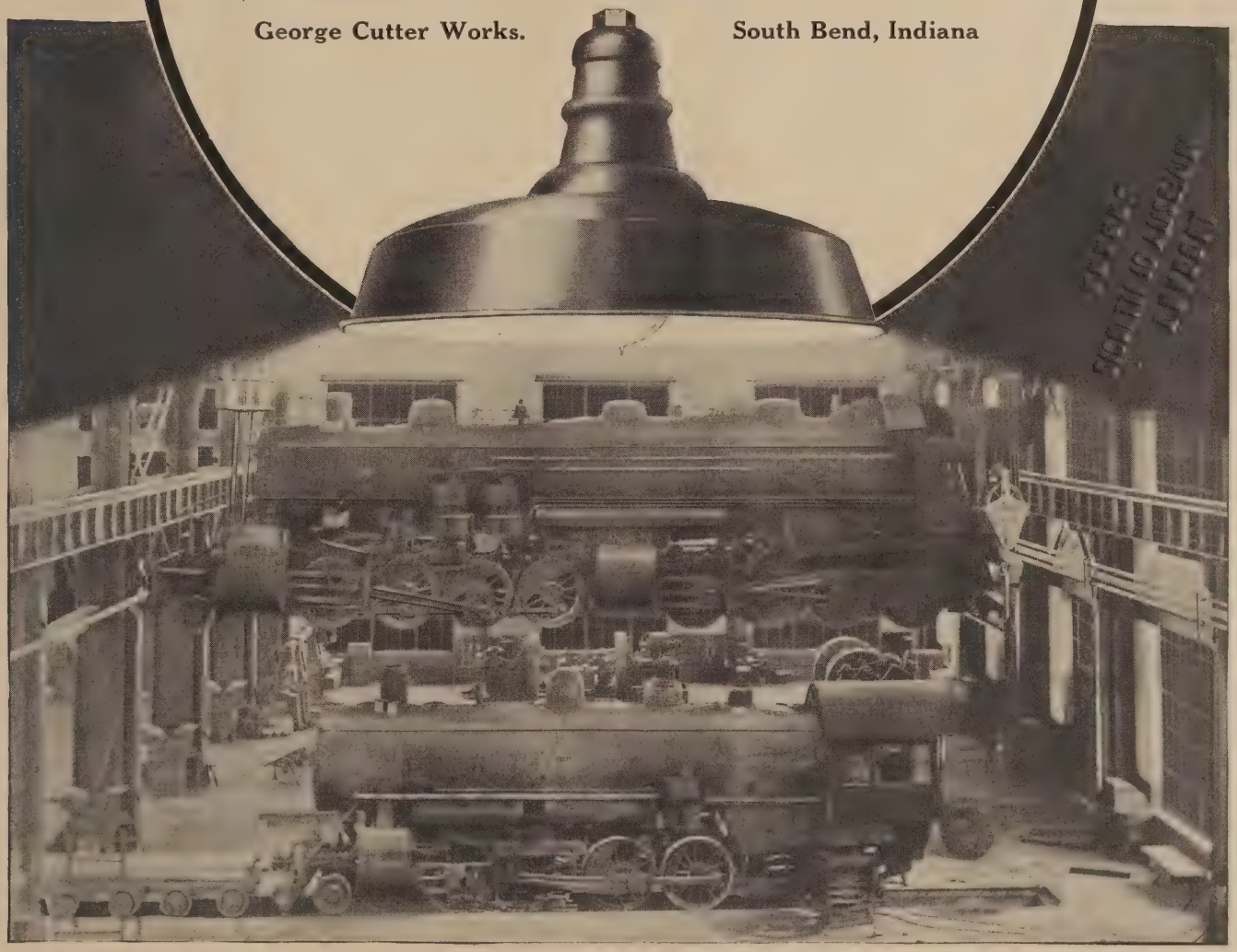

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In most shops there is enough reserve power to drive a **USL** welder from the line shafting. Only 6 horse power is required to deliver the full load current of 200 amperes.

If a shop is to be provided with only one welder, a portable **USL** outfit is in general the best proposition. If a second welder is added to the equipment it often pays to use a belted or other type of stationary welder to which the work may be brought. This latter type offers many advantages, especially as to first cost.

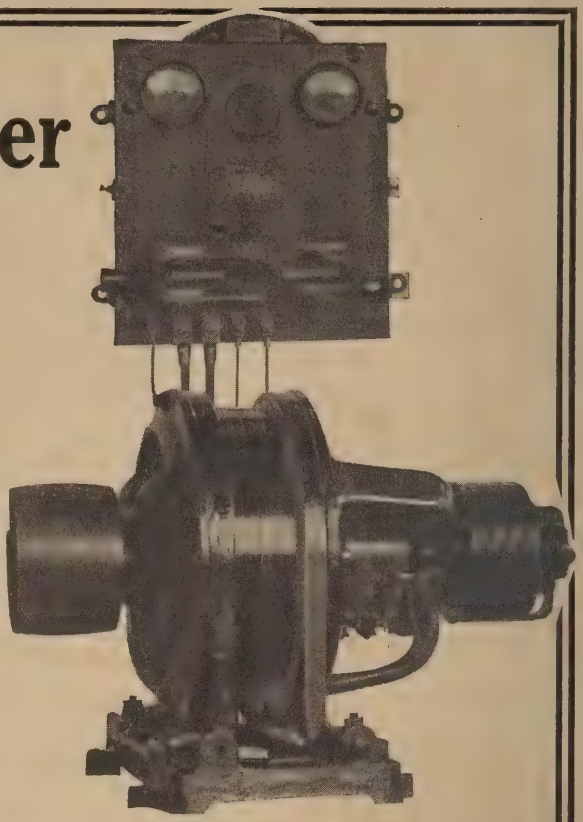
Any **USL** welder means economy in operation. This economy results from the high efficiency, ideal current and voltage characteristics which make it easy for the operator to strike, manipulate and maintain the arc under all sorts of working conditions.

The belt driven **USL** welder is identical in every respect with the electric and gasoline motor driven portable types in more general use. Mechanically it is designed and built to endure. It has ball bearings; its whole magnetic structure is laminated. The machine is sturdy and experience has shown that it will stand up under continuous duty at full load.

Practical demonstrations of the **USL** welder may be arranged for and our corps of experienced engineers is at your service to assist in solving welding problems.

Employees of those purchasing **USL** arc welders will be given a complete course in welding.

If interested write today and arrange for an interview with a **USL** representative.



Belt-Driven Stationary Type USL Arc Welder

Specifications

Current range, 50-200 amperes.
Constant energy at arc.
Adjustment in 3 to 5 ampere steps.
Inherent regulation.
No automatic or other regulators.
Polarity reversing switch.
Ball bearings.
Speed, 1,400-1,800 R. P. M.
Weight, 650 pounds.
Price, including generator, reactor, pulley, panel and sliding base, $570.
Canadian price on application.

USL
ELECTRIC ARC WELDER

U. S. Light & Heat Corporation

NIAGARA FALLS, N. Y.

U. S. Light & Heat, Ltd., Niagara Falls, Ontario

Manufacturers of

USL Arc Welders
USL Storage Batteries
USL Car Lighting Devices

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